IN THE UNITED STATES DISTRICT COURT
FOR THE DISTRICT OF DELAWARE

POLAROID CORPORATION,	)	
	)	
Plaintiff,	)	
	)	
v.	)	C.A. No. 06-738 (SLR)
	)	
HEWLETT-PACKARD COMPANY,	)	
	)	
Defendant.	)	

PLAINTIFF POLAROID CORP.'S OPENING CLAIM CONSTRUCTION BRIEF

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January 11, 2008

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I. INTRODUCTION

Plaintiff Polaroid Corporation ("Polaroid") brought this action against Hewlett-Packard Company ("HP") for infringement of U.S. Patent No. 4,829,381 (the "'381 patent") (Ex. 1). In accordance with the Amended Scheduling Order, the parties have exchanged contentions regarding constructions of the disputed claim terms and submitted a Joint Claim Construction Statement. (D.I. 90).

Polaroid's proposed constructions are based on their plain and ordinary meaning as used in the claims and the specification. They are consistent, claim to claim, and cover the invention's full scope, rather than just a preferred embodiment.

II. ELECTRONIC IMAGE ENHANCEMENT TECHNOLOGY

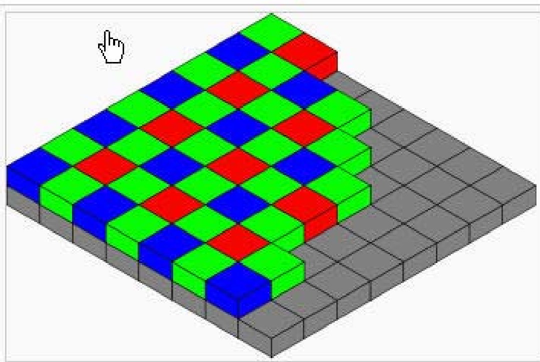
The asserted claims of the '381 patent relate to the enhancement of digital images. The patented system and method bolster the contrast in regions of an image where otherwise it would be hard to discern contrast, such as very bright or dark areas. The patented invention only bolsters contrast in the regions that need it, while leaving the rest alone. It accomplishes this by examining information about points in the image, or "pixels," as well as the collected information on other pixels in a region around that pixel, and analyzing the data using a mathematical algorithm to determine the optimal pixel value.

A. Background of the Technology

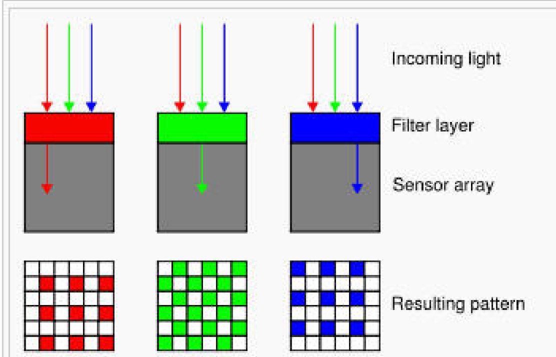
Digital devices, like printers or scanners, capture images by sensing scene light that hits photosensitive arrays, which at the time of the invention might contain 500,000 pixels, but today

contain more. (Ex. 1, '381 Pat. 3:6–14; 20–24)[1]. Each pixel then generates data about how much light hit it. The information about each pixel's location and level of light captured is then used to define the image. (*Id.*, 1:35–37; 2:63–68).

Pixels, by themselves, only capture the level of light; they cannot distinguish color. In order to generate color images, filters are laid over the pixels in a particular pattern, so that only one color of light hits each pixel. (*Id.*, 3:25–29). One common filter pattern is limited to red, green, and blue light, and the resulting signals from the pixels then measure the amount of either red, green, or blue light hitting that individual pixel. (*Id.*, 3:20–34). An example of such a filter pattern, and how it works, is shown below[2]:



The Bayer arrangement of color filters on the pixel array of an image sensor



Profile/cross-section of sensor

If filters are not used, the pixels merely measure pure brightness, sometimes called "luminance," and the image will be in black and white. Ex. 2, Wayne Niblack, AN INTRODUCTION TO DIGITAL IMAGE PROCESSING 25 (Prentice-Hall International (UK) Ltd. 1986). Or, the color electronic

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1 Citations to the '381 patent follow the standard that the first number references the column of the patent and the second number references the line within the column. For example, 3:6–14 refers to column 3, lines 6 through 14.

2 *See* <http://en.wikipedia.org/wiki/Bayer_filter, last visited on January 8, 2008.>

information signal may be converted to a luminance electronic information signal using an equation. (Ex. 1, '318 Pat., 3:38–43). Another way of characterizing pixel information that is not implicated in this case is "chrominance" which is essentially the amount of color at a particular pixel, rather than the level of light received. (*Id.*, 3:35–38; Ex. 2, Wayne Niblack, AN INTRODUCTION TO DIGITAL IMAGE PROCESSING at 32).

In practice it is difficult to capture the wide range of light seen by human beings using electronic equipment. (Ex. 1, '381 Pat., 1:26–30). When images are subsequently retrieved from the storage media for viewing or printing, detail that was visible in the original scene is sometimes lost. (*Id.*, 1:30–35). This happens because the original scene light data is compressed to fit the specifications that the equipment allows. (*Id.*, 1:30–35). A result can be lost detail, or contrast, in regions where different elements have a similar level of light. (*Id.*, 1:35–40).

B. The '381 Patent's Solution to Lost Contrast

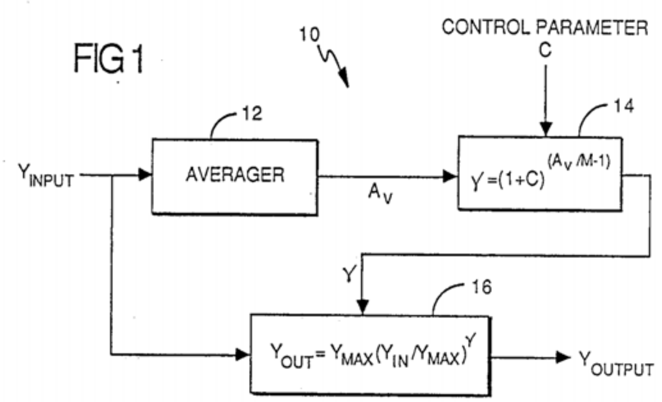
The invention disclosed in the '381 patent improves the contrast in regions of digital images where general light levels are very high or very low, making it difficult to distinguish details in those regions. (*Id.*, '381 Pat., 2:57–62). The invention increases minor variations in the light level of various features in those regions, which increases the contrast between those specific features and allows them to stand out. (*Id.*)

The Summary of the Invention section discloses the general invention. Electronic information signals corresponding to pixels are first sent to the patented system. (*Id.*, 3:1–6; Fig. 1). The invention then calculates an average signal for a pixel in an area around a particular pixel. (*Id.*, 3:59–61). The patent teaches that a low pass filter or a block average can be used to average the select group of pixels. (*Id.*, 3:61–67). A low pass filter, for example, is known as a "smoothing filter" in the art of digital imaging processing. Ex. 2, Wayne Niblack, AN INTRODUCTION TO DIGITAL IMAGE PROCESSING at 69. It reduces noise, detail, or "busyness" in

an image by calculating a variety of averages, including a weighted average, for groups of signals. *Id.* at 77–81. Block averaging, on the other hand, calculates a simple arithmetic average for the group of signals. (Ex. 1, ’381 Pat., 3:67–4:4).

The invention then uses mathematical algorithms that, where appropriate, change the value of that individual pixel to increase the difference between the value of that single electronic information signal and the average value of the signals around it. (*Id.*, 4:26–65). The invention then repeats the same process for the next pixel, using a slightly different group of pixels for the averaging because the location of the central pixel has changed. (*Id.*, 3:61–67). In that way, the invention increases the contrast in regions of an image with either high or low scene light. (*Id.*, 4:26–65).

Figure 1 illustrates the patented invention, providing the detailed algorithms:



The electronic information signals are received at Y_{INPUT}. (*Id.*, 3:1–6; Fig. 1). Each electronic information signal corresponds to a particular pixel in the image. (*Id.*, 1:68–2:1). The location of the pixel that is being transformed determines which electronic information signals are averaged. (*Id.*, 3:59–61; 67–4:4). That average is then used to calculate a value for “gamma” (γ) that will be used to select the amount of contrast enhancement:

$$\gamma = (1+C)^{(Av/M-1)}$$

(*Id.*, Fig. 1; 4:26–33). In this equation, C is a constant. (*Id.*, 5:19–21; Fig. 3). A_v is the average electronic information signal. (*Id.*, 3:63–64). And M is any value within the dynamic range of the electronic information signals. (*Id.*, 4:39–44). These factors combine to determine how much contrast enhancement to apply, which γ represents. (*Id.*, 5:8–15.)

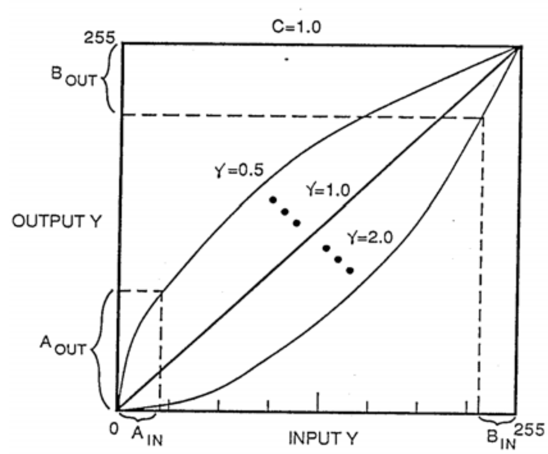
After γ is calculated for a particular signal, that signal must be transformed. The transforming algorithm is shown below, with γ playing a role to determine how much change occurs:

$$Y_{OUT} = Y_{MAX}(Y_{IN}/Y_{MAX})^{\gamma}$$

(*Id.*, Fig. 1; 8:56–65). In this equation, Y_{OUT} is the value of the transformed electronic information signal. (*Id.*, 4:67–5:3). Y_{MAX} is the highest value of the dynamic range for the electronic information signals. (*Id.*, 4:66–68). And Y_{IN} is the value of the electronic information signal received at Y_{INPUT}. (*Id.*, 4:59–61).

The graph of these algorithms illustrates how the invention works and is shown in Figure 2:

FIG 2



In Figure 2, γ will be close to 2 when the region is brightly lit. (*Id.*, 5:22–28). What this figure shows, for example, is that when Y_{INPUT} is in a bright (high value) region and has a high value close to the maximum (B_{IN}), the output value will be reduced (to B_{OUT}) to draw a greater contrast with other objects in the brightly-lit region. The opposite is true in dark areas (γ = 0.5), where a low-value Y_{INPUT} (A_{IN}) will be increased in value (to A_{OUT}) to distinguish it from the low-value surrounding pixels.

The Description of the Preferred Embodiment section of the specification then details one possible embodiment of the invention. In that embodiment, the color valued electronic information signals are converted from color to luminance values before processing. (*Id.*, 6:59–60). And a specific circuit, shown in Figure 4, physically implements the algorithms:

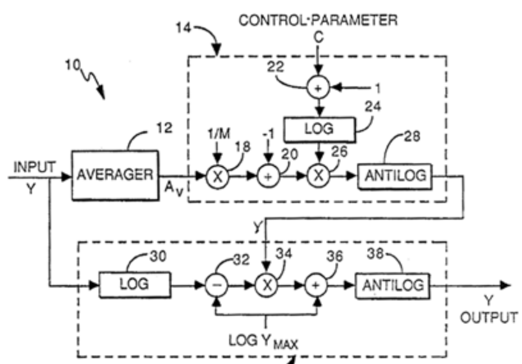


FIG 4

The equations in Figure 4, however, are slightly altered, a logarithm having been taken of the algorithms previously described. The inventors used logarithms because they are easier to implement in circuitry. (*Id.*, 7:27–39).

The Patent concludes with 13 claims, of which 1–3 and 7–9 are at issue. Claims 1–3 teach an apparatus for accomplishing this regional image enhancement, while claims 7–9 teach the method for doing so.

III. THE LAW OF CLAIM CONSTRUCTION

A. Construing Claims as One of Skill in the Art

The law of claim construction is well established. The claims of a patent define its scope, and courts interpret patent claims as a matter of law. *Phillips v. AWH Corp.,* 415 F.3d 1303, 1312 (Fed. Cir. 2005) (quoting *Innova/Pure Water, Inc. v. Safari Water Filtration Systems, Inc.*, 381 F.3d. 1111, 1115 (Fed. Cir. 2004); *see also Vitronics Corp. v. Conceptronic, Inc.*, 90 F.3d 1576, 1582 (Fed. Cir. 1996); *Markman v. Westview Instruments, Inc.*, 517 U.S. 370, 387 (Fed. Cir. 1995) (*en banc).* Claim terms usually receive their ordinary and customary meaning. *Phillips*, 415 F.3d at 1312. The ordinary and customary meaning of a claim term is the meaning that a person of ordinary skill in the art would have understood the claim to have on the filing date of the patent application. *Chiron Corp. v. Genentech, Inc*., 363 F.3d 1247, 1254 (Fed. Cir. 2004); *Phillips*, 415 F.3d at 1313.

B. Claim Construction Begins With Intrinsic Evidence

For claim construction purposes, a court presumes that one of ordinary skill in the art is familiar with the patent's intrinsic evidence, *i.e.* the patent claims, the patent specification, and the prosecution history. *Phillips*, 415 F.3d at 1313. Thus, claim construction begins with consideration of the intrinsic evidence. *Id.*

Review of the intrinsic evidence begins with the claims themselves, which provide guidance as to the meaning of claim terms. *Phillips*, 415 F.3d at 1314. For example, the context in which a term is used and the similarities and/or differences with other claims in the same patent can be instructive in claim interpretation. *Id*. In addition to the claim language itself, courts look to the patent's specification when construing a patent's claims. A patent's specification is often the best guide to understanding the meaning of a disputed claim term. *Abraxis Bioscience, Inc. v. Mayne Pharma (USA) Inc*., 467 F.3d 1370, 1376 (Fed. Cir. 2006).

"[I]t is axiomatic, however, that claims, not the specification embodiments, define the scope of the claims." *Dow Chem. Co. v. Sumitomo Chem. Co.*, 257 F.3d 1364, 1378 (Fed. Cir. 2001) (internal citation omitted). The court, therefore, must take care in its analysis when locating in the written description the context for a disputed term, not to import a limitation from that written description. *Playtex Prods., Inc. v. Procter & Gamble Co.*, 400 F.3d 901, 906 (Fed. Cir. 2005). The written description merely provides enlightenment, not limitations. *Varco, L.P. v. Pason Systems USA Corp.*, 436 F.3d 1368, 1372 (Fed. Cir. 2006) (quoting *CollegeNet, Inc. v. ApplyYourself, Inc.*, 418 F.3d 1225, 1231 (Fed. Cir. 2005)); *Tehrani v. Hamilton Med., Inc.*, 331 F.3d 1355, 1362–63 (Fed. Cir. 2003) (holding that the lower court improperly imported a limitation from the specification when it interpreted a claim to describe "automatic measuring" when the claim only stated "measuring").

Where the meaning of the claims is clear from these intrinsic sources, the court should not rely upon "extrinsic" sources of evidence, those outside the patent and prosecution history, to arrive at a claim construction that is at odds with the intrinsic evidence. *Playtex Prods., Inc.*, 400 F.3d at 908 n.1; *Interactive Gift Express v. Compuserve, Inc.*, 256 F.3d 1322, 1332 (Fed. Cir. 2001); *Bell & Howell Document Mgmt. Prods. Co v Altek Sys*, 132 F.3d 701, 705 (Fed. Cir. 1997); *Vitronics*, 90 F.3d at 1583. Where ambiguity remains after a review of the intrinsic evidence, however, a court may consider extrinsic evidence to aid the claim construction process. *Storage Tech. Corp. v. Cisco Sys., Inc.*, 329 F.3d 823, 832 (Fed. Cir. 2003) (citing *Vitronics*, 90 F.3d at 1583).

C. Construction of Means-Plus-Function Claims

Claims 1 and 3 include elements with the introductory phrase "means for." The parties agree that these elements are means-plus-function elements. Construction of those elements, therefore, is governed by 35 U.S.C § 112, ¶ 6.

When the patent drafter uses the means-plus-function format for a claim term, the limitation "shall be construed to cover the corresponding structure, materials, or acts described in the specification and equivalents thereof." 35 U.S.C. § 112, ¶ 6; *Chiuminatta Concrete Concepts, Inc. v Cardinal Indus., Inc.*, 145 F 3.d 1303, 1307 (Fed. Cir. 1998). Section 112, ¶ 6 restricts the coverage of literal claim language because it "rules out the possibility that any and every means which performs the functions specified in the claim literally satisfies that limitation." *Chiuminatta,* 145 F. 3d at 1309.

The first step in analyzing a claim written in means-plus-function form is to identify the claimed function. *Lockheed Martin Corp. v. Space Sys./Loral, Inc.*, 324 F.3d 1308, 1319 (Fed. Cir. 2003); *Chiuminatta*, 145 F.3d at 1308. The court may not construe a means-plus-function limitation by "adopting a function different from that explicitly recited in the claim." *Micro Chem., Inc. v. Great Plains Chem. Co.*, 194 F.3d 1250, 1258 (Fed. Cir. 1999); *see also Creo Prods., Inc. v. Presstek, Inc.*, 305 F.3d 1337, 1344 (Fed. Cir. 2002). The function of a means-plus-function element typically follows the language "means for." *Lockheed Martin Corp.*, 324 F.3d at 1319; *Versa Corp. v. Ag-Bag Intern. Ltd.*, 66 Fed.Appx. 853, 855 (Fed. Cir. 2003).

Second, the Court should construe the meaning of the words used to describe the claimed function, using ordinary principles of claim construction. *Lockheed Martin Corp.*, 324 F.3d at 1319.

The final step in construing a means-plus-function claim element is to look to the written description to identify the structure corresponding to the function. *Id.* (citing *Micro Chem., Inc. v. Great Plains Chem. Co.*, 194 F.3d 1250, 1258 (Fed. Cir. 1996)). Structure, material, or acts are deemed corresponding only where the "specification or prosecution history *clearly* links or associates that structure to the function recited in the claim." *B. Braun Med., Inc v. Abbott Labs*,

124 F.3d 1419, 1424 (Fed. Cir. 1997) (emphasis added). The corresponding structure must actually perform the recited function, not merely enable the pertinent structure to operate as intended. *Asyst Technologies, Inc. v. Empak, Inc.*, 268 F.3d 1364, 1371 (Fed. Cir. 2001); *Micro Chem., Inc.*, 194 F.3d at 1257–58; *Chiuminatta*, 145 F.3d at 1308–09.

IV. CONSTRUCTIONS OF THE DISPUTED CLAIM TERMS

Polaroid asserts claims 1–3 and 7–9 of the '381 patent. A summary chart of the terms to be construed and Polaroid's proposed constructions is attached as Exhibit 3. The disputed terms will be discussed in the claims in which they first appear, rather than repeatedly construed every time they appear. Each term, however, should be construed consistently as it is repeated in other claims, unlike the position HP takes with its constructions.

A. Construction of Claim 1

Claim 1 consists of a preamble and two means-plus-function claim elements:

> 1. A system for continuously enhancing electronic image data received in a continuous stream of electronic information signals, each signal having a value within a determinate dynamic range of values and corresponding to one of a plurality of succeeding pixels which collectively define an image, said system comprising:
>
> means for averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged; and
>
> means for selecting one of a plurality of different transfer functions for the electronic information signal for each of the succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel and for subsequently transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said selecting and transforming means further operates to select said transfer function as a function of the ratio of the

> value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal.

Each of these three parts of the claim will be addressed separately.

1. The Preamble

The preamble of Claim 1 reads:

> A system for continuously enhancing electronic image data received in a continuous stream of electronic information signals, each signal having a value within a determinate dynamic range of values and corresponding to one of a plurality of succeeding pixels which collectively define an image, said system comprising:

Because this preamble does not limit the scope of the claims, it should not be addressed during claim construction.

a. This preamble does not limit the scope of the claim.

This Court should not construe the preamble because it is non-limiting and, therefore, is of no significance to the claim construction process. Federal Circuit law explains that preambles are generally non-limiting, particularly where they merely recite a purpose or intended use of the invention set forth in the body of the claim or do not give life, meaning and vitality to the claim. *Innova*, 381 F.3d at 1118; *C.R. Bard, Inc. v. M3 Sys., Inc.*, 157 F.3d 1340, 1350 (Fed. Cir. 1998). A preamble does not give life, meaning and vitality to a claim if the body of the claim sets forth the complete invention. *Innova,* 381 F.3d at 1118; *Altiris, Inc. v. Symantec Corp.*, 318 F.3d 1363, 1371 (Fed. Cir. 2003); *see also IMS Tech., Inc. v. Haas Automation, Inc.*, 206 F.3d 1422, 1434 (Fed. Cir. 2000) (phrase in preamble merely giving name to the structurally complete invention not limiting); *Bristol-Myers Squibb Co. v. Ben Venue Labs., Inc.*, 246 F.3d 1368, 1375 (Fed. Cir. 2001) (finding preamble non-limiting because steps of claimed method performed the same way regardless of whether purpose described in preamble is achieved).

The *Innova/Pure Water* case provides an illustrative example of a non-limiting preamble. The preamble recited "[a] filter assembly for use with a bottle ... to simultaneously cap the neck or open end and filter liquid poured out of the bottle...." *Innova/Pure Water*, 381 F.3d at 1118. The court concluded that the preamble did not limit the claim because it merely stated the purpose or intended use of the claimed filter assembly — filtering liquid poured out of the bottle — while the ensuing claim elements set forth the complete invention. *Id.*

Like the preamble at issue in *Innova/Pure Water*, Claim 1's preamble is non-limiting. The two claim elements that follow the preamble, the means for averaging signals and the means for selecting a transform function and then transforming the signal, set forth the complete invention. The preamble merely states the purpose for that invention — enhancing electronic image data received in a continuous stream of electronic information signals, each signal having a value within a determinate dynamic range of values and corresponding to one of a plurality of succeeding pixels which collectively define an image. The way the preamble begins, "a system for," demonstrates that what the preamble describes is merely the purpose, or intended use, of the claimed invention.

A further indication that the preamble merely describes the invention's purpose is that the invention would still work as intended even if the preamble were deleted. Where deletion of the preamble would not affect the invention's operation, that preamble is non-limiting. *Catalina Mktg. Int'l, Inc. v. Coolsavings.com, Inc.*, 289 F.3d 801, 808, 809 (Fed. Cir. 2002). Here, deleting the preamble would not affect the invention's operation. The only requirements are the means for averaging and the means for selecting and transforming. The electronic information signals would still be averaged and appropriately transformed, regardless of the preamble's absence.

In short, the preamble adds nothing to this highly detailed claim and thus cannot be considered to give "life and meaning" to it. *See Innova*, 381 F.3d at 1118. The court in *Altiris*, 318 F.3d at 1371, reached this conclusion in dealing with a similarly non-limiting preamble, explaining that "[the preamble] is of no significance to claim construction because it cannot be said to constitute or explain a claim limitation." Thus, because the preamble is not limiting, this Court should not construe the terms that are found solely in the preamble.

b. If construed, the preamble terms should be construed in accordance with the intrinsic evidence.

If the Court concludes that the preamble is a limitation, it will need to construe four terms: (i) "continuously enhancing"; (ii) "electronic information signals"; (iii) "electronic image data received in a continuous stream of electronic information signals"; and (iv) "each signal having a value within a determinate dynamic range of values". The first, third, and fourth terms only appear in the Claim 1 preamble, and so if the preamble is non-limiting, they would not be construed. But the second, "electronic information signals," does appear later in Claim 1 and requires construction regardless.

(1) "continuously enhancing"

Term	**Construction**
"continuously enhancing"	"successively transforming"

The parties agree that, if the Court holds that the preamble is limiting, then "continuously enhancing" is properly construed as "successively transforming."

(2) "electronic information signals"

Term	**Polaroid's Construction**	**HP's Construction**
"electronic information signals"	"signals providing pixel information, such as color, luminance, or chrominance values"	"signal(s) providing luminance pixel information

"Electronic information signals" should be construed to mean "signals providing pixel information, such as color, luminance, or chrominance values." The difference between this construction and what HP argues is that HP seeks to limit the signals to signals providing luminance information only. But the claim language and specification compel Polaroid's construction.

The claim language itself establishes that any type of electronic information signal can be an "electronic information signal," not just a luminance signal. That is why claim language refers to "electronic information signals," not "luminance signals." If the inventors had intended to limit their invention to luminance values, they could have done so by using that term instead of the more general "electronic information signals." *See Tehrani*, 331 F.3d at 1362–63 (holding that use of general term "measuring" in claim precluded construction as more specific "automatic measuring").

The specification supports this construction by discussing different types of electronic information signals other than mere luminance values, such as color values. The specification describes using arrays of pixels that collect scene light. (Ex. 1, '381 Pat., 3:1–18). Each pixel then generates a signal based on the brightness of light measured by that pixel. (*Id.*, 3:13–18). The pixels, however, just measure brightness. For the signals to correspond to color values, a filter is laid over the pixel array, allowing only light of a particular color–for example red, green, and blue–to reach the pixel. (*Id.*, 3:25–32). The specification, therefore, states that "electronic information signals" can be color values: "[t]he electronic information signal value for each pixel in this arrangement thus corresponds to a particular color." (*Id.*, 3:33–34).

After explicitly including color values within the definition of "electronic information signal," the specification goes on to explain that in the preferred embodiment, those color values

may be converted to luminance and chrominance values. (*Id.*, 3:35–38). Even under the preferred embodiment, therefore, "electronic information signals" encompass more than just luminance values.

Throughout the remainder of the discussion of the preferred embodiment, the inventors consistently include the word "luminance" when referring to luminance values, rather than the more general "electronic information signals." For example:

> The image defining ***luminanc***e electronic information signals are thereafter averaged for selected pluralities of pixels . . . .
>
> * * *
>
> The average value for the image defining ***luminance*** electronic information signal (Av) is thereafter provided to a gamma determining circuit **14** . . . .

(*Id.*; 3:59–61; 4:26–27) (emphasis added). This usage demonstrates that the inventors were specific with the term "luminance" when they intended to be. But they left that term out of the claims, and the Court should not import it through claim construction.

(3) "electronic image data received in a continuous stream of electronic information signals"

Term	**Polaroid's Construction**	**HP's Construction**
"electronic image data received in a continuous stream of electronic information signals"	"electronic data received in a successive series of signals providing pixel information, such as color, luminance, or chrominance values"	"an uninterrupted stream of received luminance image data [pixels] defining an original image to be recorded"

Because this phrase incorporates the term "electronic information signals" construed immediately above, the proper construction should incorporate the construction of that term as well. Claim terms should be construed consistently throughout the claim. *Rexnord Corp v. Laitram Corp.*, 274 F.3d. 1336, 1342 (Fed. Cir. 2001); *see also Southwall Tech. Inc. v. Cardinal IG Co.*, 54 F.3d 1570, 1579 (Fed. Cir. 1995) (holding that "[t]he fact that we must look to other

claims using the same term when interpreting a term in an asserted claim mandates that the term be interpreted consistently in all claims"). Polaroid provides this type of consistent construction, directly substituting its construction for "electronic information" signal in this phrase. As a result, this phrase encompasses "signals providing pixel information, such as color, luminance, or chrominance values," rather than just luminance values, as HP proposes.

The only remaining dispute with respect to this phrase, therefore, centers on the word "continuous." Again, the proper construction should incorporate constructions used elsewhere. Because the parties agreed above that "continuously" in the preamble means "successively," that construction should be incorporated in construing the word "continuous" in the preamble as well. Polaroid's construction does so.

Moreover, this construction of "a successive series" is consistent with the claim language. The very preamble containing this phrase also explains that the data comes from "succeeding pixels." The second claim element then emphasizes that this is a successive process, where each pixel gets evaluated and transformed, one after another:

> …selecting one of a plurality of different transfer functions for the electronic information signal ***for each of the succeeding pixels*** in a manner whereby ***each transfer function is selected as a function of the electronic information signal for one pixel*** and the average electronic information signal for the select plurality of pixels containing said one pixel and for ***subsequently transforming the electronic information signal corresponding to each pixel….***

(Ex. 1, '381 Pat., Cl. 1)(emphasis added). As this language demonstrates, the process is one that operates successively, and that is the way one of skill in the art would interpret it.

Construing "continuous stream" as "successive series" is also consistent with the specification. In the Summary of the Invention section, the inventors emphasized the successive nature of their invention as operating on "image data received in a continuous stream wherein each signal corresponds to one of a plurality of succeeding pixels." (*Id.*, 1:66–2:1). And each

time the inventors described a "continuous stream," they referred to "succeeding" pixels or "succeeding" electronic information signals:

- "electronic image data received in a ***continuous stream*** of electronic information signals, each signal of which corresponds to one of the plurality of ***succeeding pixels*** . . ." (*Id.*, 2:63–67) (emphasis added);
- "there is shown a block diagram for the system of this invention in which a ***continuous stream*** of electronic information signals each corresponding to one of a plurality of ***succeeding pixels*** from the recorded image . . ." (*Id.*, 3:1–5) (emphasis added); and
- "gamma γ changes continuously in correspondence with the average values from the ***continuous stream*** of ***succeeding*** image defining luminance ***electronic information signals*** . . ." (*Id.*, 5:9–12) (emphasis added).

Thus, based on the claim language and the specification, "continuous stream" should be construed as "successive series."

(4) "each signal having a value within a determinate dynamic range of values"

Term	Polaroid's Construction	HP's Construction
"each signal having a value within a determinate dynamic range of values"	"each signal being associated with a value that lies within a range of possible values bounded by definite limits"	"each received pixel has an associated luminance value that lies within a predetermined group of luminance values"

The first substantive dispute between the parties is the same as with "electronic information signals": whether to construe the term "value" generally, or to limit it to luminance values as HP proposes. But the claim language and the specification support the more general construction.

As with "electronic information signal," the inventors used the word "value" in the claim, not "luminance value." Moreover, as already noted, the specification explicitly refers to color values as well as luminance values:

- The electronic information signal value for each pixel in this arrangement thus corresponds to a particular color. (Ex. 1, '381 Pat., 3:33–34).
- The analog luminance electronic signal values for each pixel element of the photosensitive array for the example herein described are digitized to an 8-bit binary number…. (*Id.*, 3:43–46).

Indeed, as these examples demonstrate, when the inventors intended a particular type of value, they specified it. Viewing both the general term in the claim, therefore, and the flexible use of the term in the specification, one of skill in the art would not understand "value" to be limited to luminance.

The second substantive dispute between the parties concerns "within a determinate dynamic range of values" in the phrase. The intrinsic evidence supports the construction "within a range of possible values bounded by definite limits." The plain and ordinary meaning of "determinate" is "having defined limits." Ex. 4, MCGRAW HILL DICTIONARY OF SCIENTIFIC AND TECHNICAL TERMS 519 (4th Ed. 1989). Thus, the plain and ordinary meaning of the claim language is to require that the signal lie within a range of values bounded by definite limits.

There is nothing in the specification that requires the Court to stray from the plain and ordinary meaning of the claim language. Rather, the specification supports Polaroid's construction that the signal be bounded by definite limits. It discloses that the dynamic range has a lower limit of zero and an upper limit of 255 for an 8-bit system. (Ex. 1, '381 Pat., 3:46–48).

HP conceded that "within a determinate dynamic range of values" requires a value that lies within a predetermined group of values. But HP attempts to narrow this claim element to a group of luminance values. As explained above, such a narrowing limitation is in direct contradiction to the claims and the patent specification. Thus, the proper construction of "each signal having a value within a determinate dynamic range of values" is "each signal being associated with a value that lies within a range of possible values bounded by definite limits."

2. "Means for Averaging . . ."

Term	Polaroid's Construction	HP's Construction
"means for averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged"	**Function**–averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged	**Function**–providing an average for selected pixel values around one pixel, where the average is correlated to each pixel making up the average
	Terms used to describe the function: *"averaging"* should be construed to mean "calculating an intermediate value for" "*average*" should be construed to mean "of calculated intermediate value" *"electronic information signals"* should be construed to mean "signals providing pixel information, such as color, luminance, or chrominance values" *"average electronic information signal"* should be construed to mean "signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value."	**Terms used to describe the function:** *"averaging"*–taking an arithmetic mean of *"average*"–an arithmetic mean *"electronic information signals"*–signal(s) providing luminance pixel information *"average electronic information signal"*–No construction necessary. Alternatively, the average of the electronic information signals
	Structure–a low pass filter or block average and equivalents thereof.	**Structure**–a block averager 12 with a buffer memory that takes luminance as an input and outputs an average luminance value that is correlated to each pixel in the block, and equivalents thereof.

The parties agree that this element is a means-plus-function claim element, but disagree about the function, the meaning of the terms describing that function, and structure implicated by

this claim element. Polaroid's construction of this means-plus-function claim element is consistent with the law concerning such means-plus-function claims and the intrinsic evidence.

a. The function

The function of this means-plus-function element is "averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged," which is the language that immediately follows "means for." The Federal Circuit has repeatedly emphasized that the function in a means-plus-function claim is defined by the language that follows the "means for…" clause. *See*, *e.g.*, *Lockheed Martin Corp.*, 324 F.3d at 1319 (holding the recited function follows the phrase "means for"); *Versa Corp.*, 66 Fed.Appx. at 855 (holding the claimed function follows the language "means for"). Here, the language that follows the "means for" clause is "averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged." That is therefore the function. HP's attempt to rewrite the function, on the other hand, is legally improper.

b. The words used to describe the claimed function

Besides "electronic information signal," which was discussed above, there are three terms used to describe the claimed function that should be construed: (i) "averaging"; (ii) "average"; and (iii) "average electronic information signal".

The proper construction of "averaging" is "calculating an intermediate value for." Similarly, the proper construction of "average" is "of calculated intermediate value." And the proper construction of "average electronic information signal" is "signals providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value." These constructions are consistent with both the claim language and the specification, which

allow for "average" to encompass its full meaning, rather than limiting it to only an "arithmetic mean," as HP proposes.

The claim language does not limit the claimed "average" to a particular type of average, such as an arithmetic mean. Instead, the claim uses the general term "average." (Ex. 1, '381 Pat., 7:67; 8:2). A court construing claim terms may not unduly limit its reading of those terms. *TI Group Auto. Sys. (N. Am.), Inc., v. VDO N. Am., L.L.C.*, 375 F.3d 1126, 1136 (Fed. Cir. 2004). Rather, "a patentee is entitled to a definition that encompasses all consistent meanings" of the term. *Id.* All consistent meanings of the term "average" include more than an arithmetic mean. An average can also be a median, mode, or a weighted average. Although the result of these averages vary, they all are a calculated intermediate value. This construction is consistent with the contemporaneous dictionary definition, which defined "average" in the mathematical context as "a quantity intermediate to a set of quantities." *See* Ex. 5, THE RANDOM HOUSE DICTIONARY OF THE ENGLISH LANGUAGE 142 (2d Ed. Unabridged 1987). That definition demonstrates that there are different types of averages. For example, a grade-point average in school is not typically a simple arithmetic mean, but rather a weighted average that constitutes a calculated intermediate value.

The specification precludes any narrower construction by describing an embodiment of an average broader than an arithmetic mean. The specification teaches that a low-pass filter may be used to calculate the average. (Ex. 1, '381 Pat., 3:61–62). Low pass filters at the time calculated different types of averages, such as weighted mean, mode, and median. Ex 2, Wayne Niblack, AN INTRODUCTION TO DIGITAL IMAGE PROCESSING at 77–81.[3] Thus, "averaging"

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3 The Niblack reference uses the term "average" to refer to weighted mean, mode, and median. *See* Ex 2, Wayne Niblack, INTRODUCTION TO DIGITAL IMAGE PROCESSING at 77.

should be construed to mean "calculating an intermediate value for." "Average" should be construed to mean "of calculated intermediate value." And "average electronic information signal" should be construed to mean "signals providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value."

c. The structure

The structure associated with this function is a low pass filter or block average and equivalents thereof. (Ex. 1, '381 Pat., 3:61–68). The specification clearly associates both a low pass filter and a block average with the claimed function:

> The averager **12** may comprise a *low pass filter* as is well known in the art which operates to provide an average value electronic information signal Av corresponding to the average luminance values for a selected window or plurality of pixels that continuously changes in correspondence with each succeeding pixel value to be enhanced. Alternatively, the averager may comprise a *block average* in which a selected group or block of pixel values is averaged to provide one average value electronic information signal Av in correspondence with each pixel value of that group to be enhanced.

(*Id.*, 6:61–7:4) (emphasis added). HP's effort to limit the structure solely to a block average ignores this clear statement. A low pass filter unambiguously is a corresponding structure.

3. "Means for Selecting . . . and for Subsequently Transforming . . ."

Term	**Polaroid's Construction**	**HP's Construction**
"means for selecting one of a plurality of different transfer functions for the electronic information signal for each of the succeeding pixels . . . and for subsequently transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said selecting and transforming means further operates to select said transfer function as a function of the ratio	**Function**–"selecting one of a plurality of different transfer functions for the electronic information signal for each of the succeeding pixels whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel and for subsequently transforming the electronic	**Function**–selecting a transfer function for each incoming pixel based on the pixel value and its corresponding average electronic information signal, and based on the result of dividing a first existing data value representing the average electronic information signal by a second existing data value representing the dynamic range of the average electronic information signals.

Term	**Polaroid's Construction**	**HP's Construction**
of the value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal."	information signal corresponding to each pixel by the transfer function selected for that pixel wherein said selecting and transforming means further operates to select said transfer function as a function of the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal."	
	Terms used to describe the function: *"transfer function"* should be construed to mean function that transforms an input signal. *"electronic information signal"* should be construed to mean "signal providing pixel information, such as a color, luminance, or chrominance value" *"ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals"* should be construed as "ratio of that calculated intermediate value over a value that lies within the range of possible values" "*dynamic range of the electronic information signals*" should be construed to mean "value that lies within the range of possible values." *"average electronic information signal"* should be construed to mean "signal providing pixel information, such as a color,	**Terms used to describe the function:** *"transfer function"*–function that transforms an input signal. *"electronic information signals"*–signal(s) providing luminance pixel information *"ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals"*–No construction necessary. Alternatively, the result of dividing a first existing data value representing the average electronic information signal by a second existing data value representing they dynamic range of the average electronic information signal. "*dynamic range of the electronic information signals*"–an integer representing the number of possible pixel values; for an 8-bit system, 256. *"average electronic information signal"*–No construction necessary. Alternatively, the

Term	Polaroid's Construction	HP's Construction
	luminance, or chrominance value of calculated intermediate value"	average of the electronic information signals
	Structure– $Y_{OUT} = Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$, where $\gamma = (1 + C)^{(Av/M - 1)}$, where Y_{out} is the transformed signal providing pixel information, such as a color, luminance, or chrominance value, Y_{MAX} is the highest value of the dynamic range, Y_{in} is the input signal providing pixel information, such as a color, luminance, or chrominance value, C is a chosen number, A_v is a calculated intermediate value, and M is any value within the dynamic range, and equivalents thereof.	**Structure**–none (indefinite). Alternatively, a gamma determining circuit 14 containing a multiplier circuit 18, a combining circuit 20, a second combiner circuit 22, a log circuit 24, a multiplier circuit 26 and a antilogarithmic determining circuit 28–all arranged according to Fig. 4, which computes $\gamma = (1 + C)^{(Av/M - 1)}$, where A_v is average luminance input, C is a constant and M equals one half of the dynamic range and the transfer function imposing circuit 16 containing a logarithm determining circuit 30, a combiner circuit 32, a multiplier circuit 34, a second combiner circuit 36 and an antilogarithm determining circuit 38–all arranged according to Fig. 4, which computes an output luminance: $Y_{OUT} = Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$, where Y_{OUT} is the output luminance value, Y_{MAX} is the maximum value in the dynamic range (255), Y_{IN} is the input pixel value, and γ is the "means for selecting a transfer function" and equivalents.

The parties agree that this second element of Claim 1 is a means-plus-function element but again dispute the function, the meaning of the terms describing that function, and the corresponding structure. Polaroid's construction of this means-plus-function claim element is consistent with the law concerning means-plus-function claims, and the intrinsic evidence compels Polaroid's construction of the terms used to describe that function.

a. The function

The description that follows the phrase "means for…" defines the function of this means-plus-function claim element and includes both selecting and transforming. *See Lockheed Martin Corp.*, 324 F.3d at 1319 (holding the claimed function follows the language "means for). As already explained, Federal Circuit law dictates that the language following that phrase is what describes the function in a means-plus-function claim element. HP's effort to re-write the function ignores the law.

b. The words used to describe the claimed function

Two of the terms used to describe the function are discussed above — "electronic information signal" and "average electronic information signal" — and they should be construed consistently here. That leaves three terms to construe: (i) "transfer function"; (ii) "ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals"; and (iii) "dynamic range of the electronic information signals".

As a threshold matter, the parties agree that "transfer function" should be construed to mean "function that transforms an input signal".

With respect to the other two terms, the first, "ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals," includes the second, "dynamic range of the electronic information signals," and that is the only time the second phrase appears. It is only necessary, therefore, to construe the first phrase.

One of skill in the art would construe "ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals" as "ratio of that calculated intermediate value over a value that lies within the range of possible values." This construction is consistent with the construction of the term "average electronic information signal" in the claim language discussed above. The average is a calculated intermediate value.

And the claim term "ratio" requires just that–a ratio with both a numerator and a denominator. The dispute between the parties centers on what that denominator in the ratio should be.

The specification clearly demonstrates that the ratio being claimed is the "ratio of the calculated intermediate value over a value that lies within the range of possible values." The only ratio the specification describes is one where the average electronic information signal is divided by a number, M. (*Id.*, 4:31–36). The specification goes on to explain that "M may be selected to be any value within the dynamic range of the electronic information signals…." (*Id.*, 4:39–42). This ratio is then represented numerous times throughout the patent as:

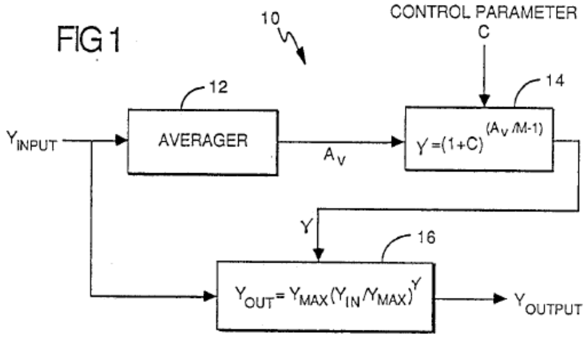
$$A_V/M$$

(*Id.*, Fig. 1, 4:32, 6:56, 8:47, 10:22). Thus, one of skill in the art would understand that the denominator in this ratio could be any value within the range of possible values. Accordingly, "ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals" should be construed to mean "ratio of that calculated intermediate value over a value that lies within the range of possible values." As a result, if the Court chooses to separately construe "dynamic range of the electronic information signals," the proper construction is "value that lies within the range of possible values."

c. The structure

The corresponding structure for accomplishing the function is the algorithm $Y_{OUT} = Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$, where $\gamma = (1 + C)^{(Av/M - 1)}$, and equivalents thereof. The specification teaches that gamma (γ) is calculated using the following algorithm: $\gamma = (1 + C)^{(Av/M - 1)}$. (Ex. 1, '381 Pat., 4:26–34; Fig. 1). According to the specification, gamma is then directed to the algorithm for Y_{OUT} to transform the electronic information signals according to the transfer function selected. (*Id.*, 4:56–65; Fig. 1). Figure 1 of the patent shows how the claimed system enhances electronic information signals using these algorithms:

FIG 1



While HP initially contends that there is no disclosed structure, it concedes that if there is one, these equations are the appropriate place to look for that structure. Five disputes remain, however.

One dispute between the parties is whether the structure implementing these algorithms is limited to the circuitry of the preferred embodiment shown in Figure 4 of the patent, or more generally to the system for implementing these algorithms, such as that shown in Figure 1 above.

Patent law requires that the more general construction apply, because anything else would restrict the claim to the single preferred embodiment. The structure in a means-plus-function claim is not limited to the preferred embodiment, but rather includes all disclosed structures and their equivalents. *Micro Chem. Inc. v. Great Plains Chem. Co.,* 194 F.3d 1250, 1258 (Fed. Cir. 1999). The '381 patent specification demonstrates that the more general construction applies, rather than the circuitry described as the preferred embodiment. Neither of the first two sections of the specification, the Background to the Invention nor the Summary of the Invention, discusses specific circuitry, or even mentions the word "circuit." Instead, the Summary of the Invention describes a "system" for enhancing images, without further limitation. (Ex. 1, '318 Pat., 1:66–68). The specification then describes Figure 1 as "a block diagram showing ***the system*** for enhancing electronic image data in the manner of this invention," again without further limitation. (*Id.*, 2:39–41) (emphasis added).

The circuitry in Figure 4 that HP points to, however, is only a preferred embodiment of the invention. The specification describes Figure 4 as only one possible system for implementing the invention: "Figure 4 is a block diagram showing in substantially more detail ***a system*** for enhancing electronic image data of this invention in the manner of FIG. 1." (*Id.*, 2:48–50) (emphasis added). And the specification only discusses Figure 4 in the section titled "Description of the Preferred Embodiment." Moreover, the algorithms shown in Figure 4 are different from those shown in Figure 1, because they have been "converted … by taking the logarithm on both sides of the aforementioned equations." (*Id.*, 6: 47–49). Thus, the circuitry in Figure 4 is merely the preferred embodiment, not the general structure for implementing the invention. As a matter of law, therefore, the construction should not limit the structure to Figure 4, but rather to the algorithms shown in Figure 1.

The parties also dispute the construction of the variables Y_{OUT}, Y_{IN}, Y_{MAX} , and C contained in the algorithms. The parties agree that Y_{OUT} and Y_{IN} are the output and input signal values, respectively, but disagree about whether those values must be limited to luminance values only. As already explained during the construction of "electronic information signals," however, those signal values may include other values, like color, as well as luminance. Only the preferred embodiment is limited to luminance, and such a limited construction would be legally improper, as well as contrary to the way one of skill in the art would construe these variables.

The parties also agree that the proper construction for Y_{MAX} is the highest value of the dynamic range in a particular system. But that dynamic range could be any value, depending on the chosen range, not limited to the highest possible value for the range in the preferred embodiment–255. The specification explicitly states that "Y_{MAX} equals the highest value of the

dynamic range for the electronic information signals." (*Id.*, 4:66–67). Although the specification states that Y_{MAX} could be 255, it also explicitly states that 255 is the maximum value of the dynamic range for the example described therein. (*Id.* at 4:67–68).

The proper construction for C is "chosen number." HP concedes that C as used in the equation $\gamma = (1 + C)^{(Av/M - 1)}$ "is a constant." D.I. 90, Joint Claim Construction Statement. The specification teaches that the system designer can select any value for C. (*Id.*, 6:32–43). Indeed, Figure 3 of the patent shows several possible values for C:

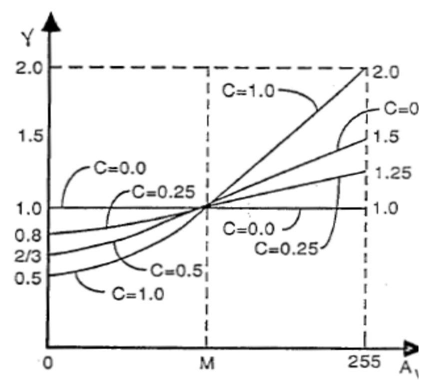


FIG 3

For reasons already discussed, A_v is the average electronic information signal, not merely an average luminance value as HP contends. And despite HP's attempt to limit it to the preferred embodiment, M is "any value within the dynamic range of the electronic information signals." (*Id.*, 4:34–44).

B. Construction of Claim 3

Claim 3 reads as follows:

> 3. The system of claim 2 wherein said selecting and transforming means further operates to select said transfer function as a function of a determined constant whose value corresponds to the amount of contrast provided in those areas of higher contrast provided by said select transfer function.

Term	Polaroid's Construction	HP's Construction
"wherein said selecting and transforming means further operates to select said transfer function as a function of a determined constant whose value corresponds to the amount of contrast provided in those areas of higher contrast provided by said select transfer function."	**Function**–selecting one of a plurality of different transfer functions for the electronic information signal for each of the succeeding pixels and for subsequently transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said selecting and transforming means further operates to select said transfer function as a function of the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal, said selecting and transforming means further operates to select said transfer function as a function of a determined constant whose value corresponds to the amount of contrast provided in those areas of higher contrast provided by said select transfer function.	**Function**–a control parameter
	Structure– $Y_{out} = Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$, where $\gamma = (1 + C)^{(Av/M - 1)}$, where Y_{out} is the transformed signal providing pixel information, such as a color, luminance, or chrominance value, Y_{MAX} is the highest value of the dynamic range, Y_{in} is the input signal providing pixel information, such as a color, luminance, or chrominance value, C is a chosen number, A_v is a calculated intermediate value, and M is any value within the dynamic range, and equivalents thereof.	**Structure**–the control parameter C employed in the second combiner function within the gamma determining circuit and equivalents

The parties agree that Claim 3 is a continuation of the selecting and transforming means in Claim 1.[4] The parties disagree, however, on the claimed function and corresponding structure.

1. The function

The function of this means-plus-function element follows the phrase "means for" in Claim 1 and continues with the further function claimed in Claim 3. Therefore, the complete function for the "selecting and transforming means" claimed in Claim 3 is set forth in the table immediately above. The additional function required by Claim 3 is "to select said transfer function as a function of a determined constant whose value corresponds to the amount of contrast provided in those areas of higher contrast provided by said select transfer function." HP's third effort to re-write the function should be rejected.

2. The structure

The structure for this means-plus-function element is the same as that described with respect to the "means for selecting and transforming" found in Claim 1 and equivalents thereof. A chosen number, C, is specifically responsible for the additional function claimed in Claim 3. The specification clearly associates the constant, C, with this additional function. (*Id.*, 4:51–54). As explained previously, the specification dictates that the constant C can be any chosen number.

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4 Claim 3 depends from Claim 2, which itself depends from Claim 1. Claim 2 reads: "The system of claim 1 wherein said selecting and transforming means is responsive to an average electronic information signal indicative of low scene light intensity levels for transforming the electronic information signals to provide a higher contrast to those electronic information signals corresponding to pixels having the lowest scene light intensity levels and is further responsive to an average electronic information signal indicative of high scene light intensity levels for transforming the electronic information signals to provide a higher contrast to those electronic information signals corresponding to pixels having the highest scene light intensity levels."

C. Construction of Claim 7

Claim 7 is a method claim with a preamble and three separate claim elements, and its language almost exactly matches the language of Claim 1:

> 7. A method for continuously enhancing electronic image data received in a continuous stream of electronic information signals each signal having a value within a determinate dynamic range of values and corresponding to one of a plurality of succeeding pixels which collectively define an image, said method comprising the steps of:
>
> - averaging the electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels;
> - selecting one of a plurality of different transfer functions for the electronic information signal for each of the plurality of succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel; and
> - transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said transfer function is selected further as a function of the ratio of the value of the average electronic information signal to a select proportionate value of the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal.

The construction of Claim 7, therefore, should be consistent with the construction of Claim 1. *See Rexnord*, 274 F.3d. at 1342 (holding "claim terms found in different claims should be interpreted consistently."); *Southwall Tech.*, 54 F.3d at 1579 (holding "[t]he fact that we must look to other claims using the same term when interpreting a term in an asserted claim mandates that the term be interpreted consistently in all claims.").

1. The Preamble

The preamble of Claim 7 is just the method-claim version of the same preamble as appears in Claim 1:

> A method for continuously enhancing electronic image data received in a continuous stream of electronic information signals, each signal having a value within a determinate dynamic range of values and corresponding to one of a plurality of succeeding pixels which collectively define an image, said method comprising:

(Ex. 1, ’381 Pat., 9:42–48). Just as with Claim 1, the preamble of Claim 7 does not limit the scope of the claim. If the Court disagrees, however, it should construe the disputed terms as it construed those same terms in Claim 1:

- “continuously enhancing” should be construed as “successively transforming.”
- “electronic image data received in a continuous stream of electronic information signals” should be construed as “electronic data received in a successive series of signals providing pixel information, such as color, luminance, or chrominance values.”
- “each signal having a value within a determinate dynamic range of values” should be construed as “each signal being associated with a value that lies within a range of possible values bounded by definite limits.”

2. The First and Second Claim Elements

The language of the first and second claim elements are almost identical to the first and second elements of Claim 1, except that they are written as a method elements, rather than as means-plus-function elements. Therefore, the same terms construed in the first element of Claim 1 should also be construed in this element of Claim 7, and they appear in bold below:

> ***[A]veraging*** the ***electronic information signals*** corresponding to selected pluralities of pixels and providing an ***average electronic information signal*** for each said plurality of pixels;

(*Id.*, lines 49–52). Terms in this claim should be construed consistently with the constructions from Claim 1. Those constructions are:

- "averaging" should be construed to mean "calculating an intermediate value for."
- "electronic information signals" should be construed to mean "signals providing pixel information, such as color, luminance, or chrominance values."
- "average electronic information signal" should be construed to mean "signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value."

After applying those constructions, the first element of Claim 7 would read:

> ***Calculating an intermediate value for*** the ***signals providing pixel information, such as color, luminance, or chrominance values*** corresponding to selected pluralities of pixels and providing a ***signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value*** for each said plurality of pixels;

Similarly, the same terms construed in the second element of Claim 1 should also be construed in this second element of Claim 7:

> [S]electing one of a plurality of different ***transfer functions*** for the ***electronic information signal*** for each of the plurality of succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the ***average electronic information signal*** for the select plurality of pixels containing said one pixel;

(*Id.*, lines 53–60). The proper constructions are:

- "transfer function" should be construed to mean "function that transforms an input signal."
- "electronic information signal" should be construed to mean "signal providing pixel information, such as a color, luminance, or chrominance value."
- "average electronic information signal" should be construed to mean "signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value."

After applying those constructions, the second element of Claim 7 would read:

> [S]electing one of a plurality of different ***functions that transform an input signal*** for the ***signal providing pixel information, such as a color, luminance, or chrominance value*** for each of the plurality of succeeding pixels in a manner whereby each ***function***

> ***that transforms an input signal*** is selected as a function of the ***signal providing pixel information, such as a color, luminance, or chrominance value*** for one pixel and the ***signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value*** for the select plurality of pixels containing said one pixel;

These constructions for the first and second elements fully explain the claim element for a lay jury consistently with the meaning as understood by one of skill in the art, while capturing all nuances of the claims as drafted. This approach of substituting the construed terms within the claim elements, rather than re-writing the claim elements from scratch, is the correct approach. *See Vivid Tech. v. ASE*, 200 F. 3d 795, 803 (Fed. Cir. 1999) (holding only those terms need be construed that are in controversy, and only to the extent necessary to resolve the controversy). The re-writing that HP proposes would also result in inconsistency with the other claims, which is to be avoided. *Rexnord*, 274 F.3d. at 1342; *see also Southwall Tech.*, 54 F.3d at 1579 (holding that "[t]he fact that we must look to other claims using the same term when interpreting a term in an asserted claim mandates that the term be interpreted consistently in all claims").

3. The Third Claim Element

As with the first two claim elements, the language of the third claim element almost exactly replicates that found at the end of Claim 1:

> [T]ransforming the ***electronic information signal*** corresponding to each pixel by the ***transfer function*** selected for that pixel wherein said ***transfer function*** is selected further as a function of the ratio of the value of the ***average electronic information signal*** to a select proportionate value of the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the ***average electronic information signal***.

(Ex. 1, '381 Pat., 9:61–10:2). Each of the bolded terms above have been addressed with respect to the second claim element and should be construed consistently here.

There is one additional term, however, that appears within the third claim element: "a select proportionate value of the dynamic range of the electronic information signals." That term should be construed as "a value within the range of possible values." This construction is consistent with both the claim language and the specification.

Just as with Claim 1, this element of Claim 7 claims a ratio with a numerator and a denominator. The claim states that the denominator of the ratio is "a select proportionate value of the dynamic range of the electronic information signals." (*Id.*, 9:66–67). One of skill in the art would understand from reading the specification that a select proportionate value of the dynamic range is a value within the range of possible values. The specification discloses that for an 8-bit system, the dynamic range has a lower limit of zero and an upper limit of 255. (*Id.*, 3:47–48). Thus, when reading the claim in the context of the specification, one of ordinary skill in the art would understand the claimed value to be a value within the range of possible values.

The specification supports Polaroid's construction. As explained earlier, the only ratio disclosed in the specification is Av/M, where "M may be selected to be any value within the dynamic range of the electronic information signals . . ." (*Id.*, 4:39–42). Thus, it is clear from the specification that the denominator of the ratio is a value within the range of possible values. Accordingly, "a select proportionate value of the dynamic range of the electronic information signals" should be construed to mean "value within the range of possible values."

After applying these constructions, the third element of Claim 7 would read:

> [T]ransforming the ***signal providing pixel information, such as a color, luminance, or chrominance value*** corresponding to each pixel by the ***function that transforms an input signal*** selected for that pixel wherein said ***function that transforms an input signal*** is selected further as a function of the ratio of the value of the ***signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value*** to ***a value within the range of possible values*** such that the ratio increases in

> correspondence with the increase in the value of the ***signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value***.

These constructions fully explain the claim element for a lay jury consistent with the meaning as understood by one of skill in the art.

D. Construction of Claim 9

Claim 9 is also a method claim, and its language is very close to the language of Claim 3:

> 9. The system of claim 8 wherein said ***transfer function*** is selected further as a function of a ***determined constant*** wherein increasing the value of said constant operates to increase the contrast in those areas of higher contrast provided by said select ***transfer function***.

The parties agree that "transfer function" should be construed as "function that transforms an input signal." The only term in dispute, therefore, with respect to this claim is "determined constant." That phrase is basic enough that the lay jury will understand it. But should the Court decide to construe the phrase, it should do so consistently with the construction of the constant C identified in Claim 1: "chosen number."

V. CONCLUSION

The intrinsic evidence, including the claim language and the specification, compels the constructions set forth above. Polaroid thus respectfully requests that this Court enter an order adopting its proposed constructions, rather than narrowing the claims to the preferred embodiment or construing terms inconsistently from claim to claim, as HP argues.

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January 11, 2008
1380096

CERTIFICATE OF SERVICE

I, the undersigned, hereby certify that on January 11, 2008, I electronically filed the foregoing with the Clerk of the Court using CM/ECF, which will send notification of such filing(s) to the following:

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EXHIBIT 1

United States Patent [19] [11] Patent Number: 4,829,381
Song et al. [45] Date of Patent: May 9, 1989

[54] SYSTEM AND METHOD FOR ELECTRONIC IMAGE ENHANCEMENT BY DYNAMIC PIXEL TRANSFORMATION

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[73] Assignee: Polaroid Corporation, Cambridge, Mass.

[21] Appl. No.: 182,987

[22] Filed: Apr. 18, 1988

[51] Int. Cl.[4] H04N 5/235; H04N 5/208
[52] U.S. Cl. 358/168; 358/166; 358/32; 358/164
[58] Field of Search 358/166, 167, 36, 37, 358/168, 169, 32, 164

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[57] ABSTRACT

A system and method are provided for continuously enhancing electronic image data received in a continuous stream of electronic information signals wherein the electronic information signal corresponding to each pixel of the image recorded is selectively transformed as a function of the average value of electronic information signals for a select plurality of pixel values in the immediate area of the pixel value being transformed. The electronic information signal transformations are provided on a pixel-by-pixel basis to increase contrast in localized areas that may be either exceptionally light or dark as a result of varying scene lighting conditions.

13 Claims, 2 Drawing Sheets

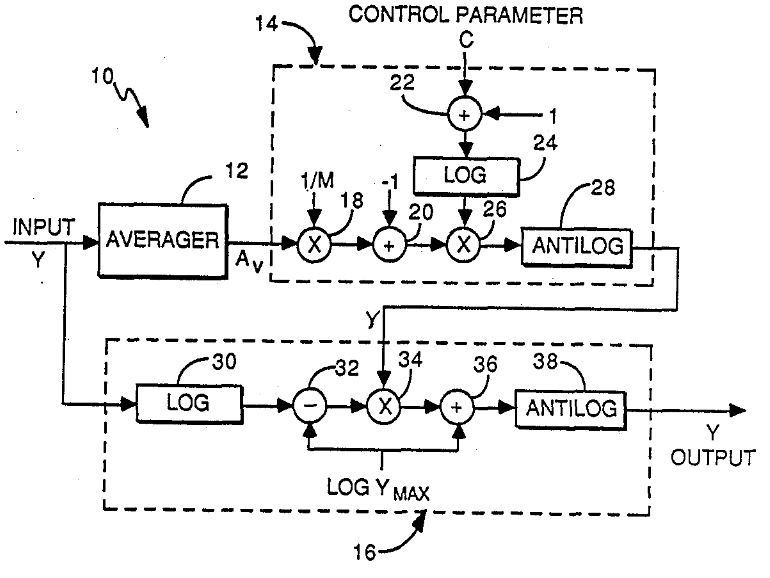
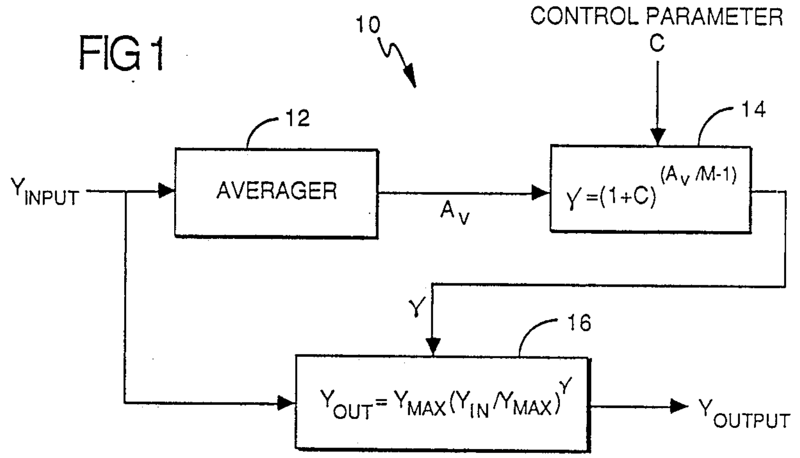
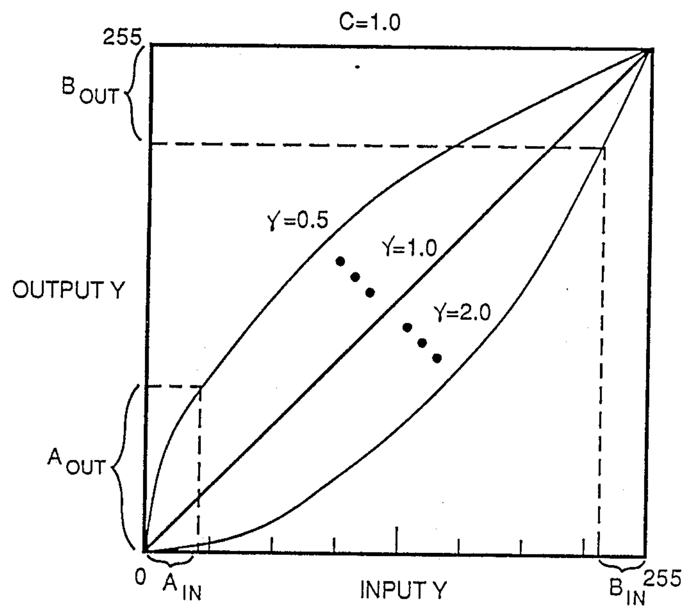


FIG 1

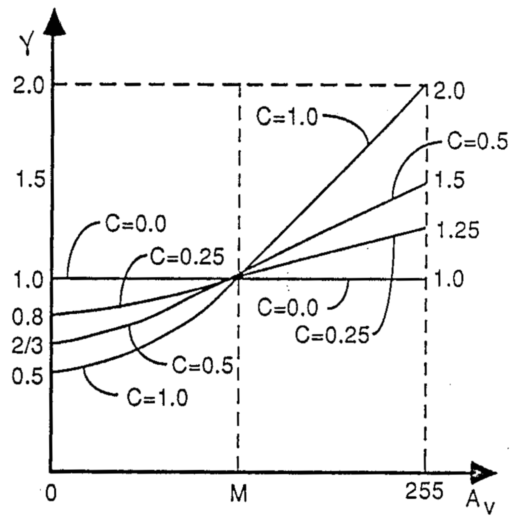


10
CONTROL PARAMETER C
12
14
Y_{INPUT}
AVERAGER
A_V
$\gamma = (1+C)^{(A_V/M-1)}$
γ
16
$Y_{OUT} = Y_{MAX}(Y_{IN}/Y_{MAX})^{\gamma}$
Y_{OUTPUT}

FIG 2

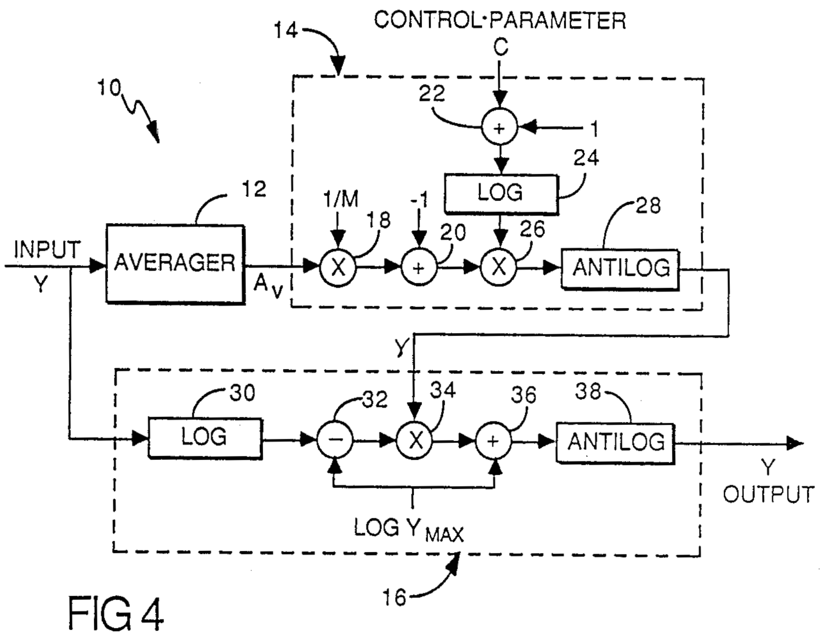


C=1.0
255
B_{OUT}
γ=0.5
γ=1.0
γ=2.0
OUTPUT Y
A_{OUT}
0
A_{IN}
INPUT Y
B_{IN}
255



Y
2.0
1.5
1.0
0.8
2/3
0.5
C=1.0
C=0.5
C=0.0
C=0.25
C=0.5
C=1.0
C=0.0
C=0.25
2.0
1.5
1.25
1.0
0
M
255
A_V

FIG 3



CONTROL·PARAMETER
C
14
10
22
1
24
LOG
12
1/M
18
-1
20
26
28
INPUT
Y
AVERAGER
A_V
X
+
X
ANTILOG
Y
30
32
34
36
38
LOG
−
X
+
ANTILOG
Y
OUTPUT
LOG Y_{MAX}
16

FIG 4

SYSTEM AND METHOD FOR ELECTRONIC IMAGE ENHANCEMENT BY DYNAMIC PIXEL TRANSFORMATION

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to a system and method for electronic image enhancement by dynamic pixel transformation and, more particularly, to a system and method for enhancing electronic image information by dynamically transforming electronic information signals on a pixel-to-pixel basis.

2. Description of the Prior Art

Electronic still image cameras are becoming well known in the art. Such cameras utilize photoresponsive arrays to sense scene light and convert the sensed scene light into electronic information signals. Electronic information signals are thereafter stored on a suitable media which may include magnetic, optical or solid state storage for subsequent retrieval and viewing. It may be desirable at some point to transform the stored image defining electronic information signals to a hard copy of the scene originally recorded. Photographic media have been suggested and used for such purposes. Difficulties arise, however, as a result of differences between the wide dynamic range of the scene originally sensed and recorded and the substantially smaller dynamic range to which a photographic print may be exposed. The wide dynamic range of luminance intensities within the scene originally recorded may thus be compressed or clipped to the substantially smaller dynamic range of the photographic print, losing detail within certain portions of the dynamic range that were otherwise visible in the original scene. Thus, it may be desirable to transform the original image defining electronic information signals in a nonlinear manner to selectively increase and/or decrease the contrast and brightness in certain portions of the scene such as those that might be brightly lit by sunlight or underlit as a result of shadows. However, no single transform function can be uniformly applied to all the image defining electronic information signals of the scene and achieve satisfying results because the lighting conditions vary across the scene.

Therefore, it is an object of this invention to provide a system and method of electronically enhancing images by dynamically increasing or decreasing contrast and brightness in selected portions of the scene that may be overlit or underlit.

It is a further object of this invention to provide a system and method of enhancing image defining electronic information signals in a dynamic manner on a pixel-by-pixel basis such that the value of each pixel is selectively transformed as a function of the average value of a plurality of pixels closely spaced about that pixel.

Other objects of the invention will be in part obvious and will in part appear hereinafter. The invention accordingly comprises a mechanism and system possessing the construction, combination of elements and arrangement of parts which are exemplified in the following detailed disclosure.

SUMMARY OF THE INVENTION

A system is provided for enhancing electronic image data received in a continuous stream of electronic information signals wherein each signal corresponds to one of a plurality of succeeding pixels. The pixels collectively define the image to be recorded. Means are provided for averaging the electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each of the plurality of the pixels so averaged. Means operate to thereafter select one of the plurality of different transfer functions of electronic information signals for each of the succeeding pixels. Each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing that one pixel. The electronic information signal corresponding to each pixel is subsequently transformed by the transfer function selected for that pixel. The system responds to an average electronic information signal indicative of low scene light intensity levels by transforming electronic information signals to provide a higher contrast and/or brightness to those electronic information signals corresponding to pixels having the lowest scene light intensity levels. The system also responds to an average electronic information signal indicative of high scene light intensity levels by transforming electronic information signals to provide a higher contrast and/or lower brightness to those electronic information signals corresponding to pixels having the highest scene light intensity levels.

DESCRIPTION OF THE DRAWINGS

The novel features that are considered characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with other objects and advantages thereof will be best understood from the following description of the illustrated embodiment when read in connection with the accompanying drawings wherein:

FIG. 1 is a block diagram showing the system for enhancing electronic image data in the manner of this invention;

FIG. 2 is a graphical representation showing the output electronic information signals versus the input electronic information signals;

FIG. 3 is a graphical representation showing the variation of gamma γ with different selected control parameters; and

FIG. 4 is a block diagram showing in substantially more detail a system for enhancing electronic image data of this invention in the manner of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

In electronic image processing it is desirable to adjust the image contrast automatically to produce more detail in both the bright and dark areas of a scene that is recorded. The image enhancing system and method of this invention operates to both lighten the dark regions of a scene and darken the light regions of a scene by enhancing contrast to improve the detail visibility that would otherwise be lost when the electronic image signals are converted to a hard copy reproduction. Toward that end, the system and method of this invention operates to continuously enhance electronic image data received in a continuous stream of electronic information signals, each signal of which corresponds to one of the plurality of succeeding pixels which collectively define the recorded image.

Referring now to FIG. **1**, there is shown a block diagram for the system of this invention in which a continuous stream of electronic information signals each corresponding to one of a plurality of succeeding pixels from the recorded image are received at terminal Y_{input}. The electronic information signals input at terminal Y_{input} may be derived in a well-known manner by a two-dimensional photosensitive array or sensor (not shown) which may comprise a high resolution charge coupled device (CCD) or charge injection device (CID). The sensor receives image scene light in any well-known manner by way of an objective lens and shutter (also not shown). The image sensing array comprises a plurality of image sensing elements or pixels preferably arranged in a two-dimensional area array wherein each image sensing pixel converts the incident image defining scene light rays into a corresponding analog electronic information signal value. Preferably, the image sensing pixels are arranged in columns and rows as is well known in the art. As will be readily understood, image sensing arrays, particularly for sensing still images, preferably comprise a large number of image sensing elements or pixels in the order of 500,000 or greater.

The two-dimensional photosensitive arrays may also be overlayed with any one of a variety of different well-known filter patterns so that each pixel provides an electronic information signal value corresponding to a particular color. For instance, the columns of the two-dimensional photosensitive array may be overlayed with any one of a red, green or blue filter stripe arranged in a repeating fashion across the face thereof. The electronic information signal value for each pixel in this arrangement thus corresponds to a particular color.

The electronic information signal values retrieved from the photosensitive array in this manner are preferably converted to luminance (Y) and chrominance, e.g., (R-Y and B-Y) signal values. For the case where the two-dimensional photosensitive array is overlayed with red, green and blue filters, the luminance electronic information signals are preferably determined by the following relationship: $Y=0.30R+0.59G+0.11B$ as is well known in the television art. The analog luminance electronic information signal values for each pixel element of the photosensitive array for the example herein described are digitized to an 8-bit binary number so as to have a dynamic integer range of from 0 - 255 within which range are 256 intensity levels and a maximum luminance value of $Y_{MAX}=255$. The electronic image detection and processing herein described so far will be recognized as being conventional and well known in the art.

The image defining electronic information signals derived in the above-described manner and preferably comprising digitized luminance signals are thereafter subjected to a gain control function which may be automatic as is well known in the art before being directed to input terminal Y_{input} of the block diagram of FIG. **1**. The image defining luminance electronic information signals are thereafter averaged for selected pluralities of pixels by an averager **12**. The averager **12** may comprise a low pass filter as is well known in the art which operates to provide an average value electronic information signal Av corresponding to the average luminance values for a selected window or plurality of pixels that continuously changes in correspondence with each succeeding pixel value to be enhanced. Alternatively, the averager may comprise a block average in which a selected group or block of pixel values is averaged to provide one average value electronic information signal Av in correspondence with each pixel value of that group to be enhanced. Succeeding groups of pixel values are thereafter averaged. In the preferred mode, the selected groups of pixels are preferably selected in two dimensions from the photosensitive array.

Both low pass filtering and block averaging require a buffer memory to hold the selected groupings of pixel values for averaging as is well known in the art. The low pass filter method results in a continuing change in the average value of the electronic information signal Av for each succeeding pixel thereby providing a more accurate determination of average values for selecting the appropriate transfer function in the manner of this invention to be described. However, as will be well understood, the low pass filtering technique requires a substantially increased computational capacity in comparison to block averaging; and, therefore, block averaging, although not as highly selective as low pass filtering, may be preferred in image enhancing applications where reduced computational capacity is desired. Low pass filtering and block averaging are both well-known techniques in the electronic arts and therefore need not be described in any further detail herein.

The average value for the image defining luminance electronic information signal (Av) is thereafter provided to a gamma determining circuit **14** which determines gamma as a function of the average value input thereto in accordance with the following relationship:

$$\gamma=(1+C)(Av/M-1)$$

In the above relationship M for this example is selected to be the center value of the dynamic range of the electronic information signals. As was previously stated, the electronic signal values for this example comprise 8-bit binary numbers having a dynamic range of 256. Thus, for this example, $M=128$. However, it will be readily understood that M may be selected to be any value within the dynamic range of the electronic information signals depending upon where the least image enhancement is desired. Thus, for the case where M is selected to be at the center of the dynamic range, image enhancement will have the greatest effect near the ends of the dynamic range and the least effect toward the center of the dynamic range. Selecting the value of M to be closer to the high end of the dynamic range will decrease the effective image enhancement provided at that end by the system and method of this invention.

C is a control parameter selected in the manner of this invention to vary the amount of image enhancement that may be provided by the system and method of this invention in a manner to be more fully described in the following discussion.

The value of gamma is thereafter directed to a transfer function imposing circuit **16** which operates to impose the following transfer function on the image defining luminance electronic information signals (Y) received at input terminal Y_{input} and corresponding to each one of the succeeding pixels which collectively define the recorded image.

$$Y_{out}=Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$$

Y_{MAX} equals the highest value of the dynamic range for the electronic information signals or 255 for the example herein described. Y_{out} equals the image defining

luminance electronic information signal transformed in the manner of this invention to provide an enhanced image. As is now readily apparent, it is selected for the image defining luminance electronic information signal for each pixel as a function of a local average of image defining luminance electronic information signals for a select group or plurality of pixels closely spaced about the pixel value being enhanced or transformed. Thus, gamma γ changes continuously in correspondence with the average values from the continuous stream of succeeding image defining luminance electronic information signals so that each image defining luminance electronic information signal is enhanced or transformed by a selected one of a plurality of different transfer functions.

Referring now to FIG. 2, there is shown a graphical representation of the various transfer functions that are imposed by the transfer function circuit **16** as a function of the variation in gamma γ. For the example as shown in FIG. 2, the control parameter C is selected to equal 1 and thus it can be seen that gamma γ has a variation of from 0.5 to 2. For instance, in the situation where the average value of the image defining luminance electronic signals is high and approaches the maximum value of the dynamic range which in this example equals 255 and is indicative of a portion of the image that is extremely bright, it can be seen that gamma γ equals 1+C or as in the case where C=1, gamma $\gamma=2$ as shown in the diagram of FIG. 2. The slope of the transfer function as is readily apparent for the situation where gamma $\gamma=2$ becomes quite steep at the high end of the dynamic range (B_{in}, B_{out}) thereby providing a higher contrast to those image defining luminance electronic information signals corresponding to pixels having the highest scene light intensity levels. The slope of the transfer function for $\gamma=2$ decreases significantly at the low end of the dynamic range (A_{in}, A_{out}) thereby providing a lower contrast to those image defining luminance electronic information signals corresponding to pixels having the lowest scene light intensity levels. Since M is selected to be at the center of the dynamic range, it can be seen that the slope of the transfer function at the center of the dynamic range most closely approximates that of a straight line thereby providing the least effect on the output signal for pixels having intensity levels near the center of the dynamic range.

Conversely, in the situation where the average values of the image defining luminance electronic information signals are low approaching 0 indicative of localized areas of low scene light intensity levels, then gamma $\gamma=1$ divided by 1+C which equals 0.5 in the case where C=1. The transfer function imposed by the transfer function circuit **16** in the case where gamma γ equals 0.5 is shown graphically in FIG. 2 as comprising a substantially steep slope in the areas (A_{in}, A_{out}) where the image defining luminance electronic information signal values are low. Thus, the transfer function in this case where gamma γ equals 0.5 operates to transform the image defining luminance electronic information signals to provide a high contrast to those electronic information signals corresponding to pixels having the lowest scene light intensity levels. The slope of the transfer function for $\gamma=0.5$ decreases significantly at the high end of the dynamic range (B_{in}, B_{out}) thereby providing a lower contrast to those image defining luminance electronic information signals corresponding to pixels having the highest scene light intensity levels. Again, since M is selected to be at the center of the dynamic range, it can be seen that the slope of the transfer function at the center of the dynamic range most closely approximates that of a straight line thereby providing the least effect on the output signal for pixels having intensity levels near the center of the dynamic range. It can be seen that the transfer function imposed by the transfer function circuit **16** can have any intermediate number of transfer functions shown between the extreme end transfer functions where gamma equals 0.5 or 2.0 and that all of the transfer functions are operative for the full extent of the input dynamic range so as not to clip the input signal values.

In the situation where the average value for the image defining luminance electronic information signal values corresponds to the intermediate value of the dynamic range, gamma $\gamma=1$ and the transfer function becomes a straight line to provide a one-to-one relationship between the input and output electronic information signals with no localized increase in contrast as provided by the other transfer functions where gamma γ is either greater or less than 1. Thus, in this manner in a situation where a scene may have localized dark or bright areas, there may be provided a localized increase in the contrast to those areas to make visible details that otherwise would be lost. The transfer functions vary in correspondence with the variation in the local average scene light intensity levels so as to apply the increased contrast selectively to those light or dark portions of the scene where details are otherwise obscured.

Referring now to FIG. 3, there is shown a graphical representation of the variation in gamma γ as a function of the variation of the control parameter C. Thus, it can be seen that for a control parameter C value of 1 gamma γ varies from 0.5 to 2. If the control parameter C is selected to be 0, gamma γ remains constant at 1. Although for a typical imaging application which requires dynamic range compression, it may be satisfactory to select the control parameter C to equal 1 thereby achieving an extreme variation in gamma from 2 to 0.5, it may be desirable to increase the amount of localized contrast thereby selecting values of the control parameter C greater than 1.

Referring now to FIG. 4 where like numerals reference previously discussed components, there is shown a circuit diagram for implementing a transfer function as described in connection with FIG. 1. The aforementioned transfer function may be converted to the following relationship by taking the logarithm on both sides of the aforementioned equation.

$$\log Y_{out}=\log Y_{MAX}+\gamma(\log Y_{in}-\log Y_{MAX})$$

Similarly, the relationship for determining gamma can also be rewritten as follows:

$$\log \gamma=(Av/M-1)[\log(1+C)]$$

These relationships can be implemented as shown by the circuit of FIG. 4. The average value of the image defining luminance electronic information signal is first directed to a multiplier circuit **18** where the signal is multiplied by 1/M where M equals one-half the dynamic range of the electronic information signals as previously discussed. The output from the multiplier circuit **18**, in turn, is directed to a combining circuit **20** which operates to add a negative 1 to the output from the multiplier circuit **18**. The control parameter C is directed to a combiner circuit **22** which operates to add

a positive 1 thereto. The output from the combiner circuit **22**, in turn, is directed to a log circuit **24** which provides the logarithmic value for the C+1 input thereto. The output from the logarithmic circuit **24**, in turn, is multiplied by the output from the combining circuit **20** by a multiplier circuit **26**. The output from the multiplier circuit **26**, in turn, is directed to an antilogarithmic determining circuit **28** which operates utilizing a lookup table to provide the antilogarithm creating the value of gamma γ.

The image defining luminance electronic information signal for each pixel, in turn, is directed to a logarithm determining circuit **30** in the transfer function circuit **16**. The output from the logarithm determining circuit **30**, in turn, is directed to a combiner circuit **32** which operates to subtract therefrom the logarithm for the maximum dynamic range of the electronic information signals. The output from the combiner **32**, in turn, is multiplied by multiplier circuit **34** by the value of gamma γ received from the antilogarithm determining circuit **28**. The output from the multiplier **34**, in turn, is directed to a combiner circuit **36** for addition to the logarithm of the maximum dynamic range of the electronic information signals. The output from the combiner circuit **36**, in turn, is directed to an antilogarithm determining circuit **38** to provide the transformed image defining luminance electronic information signals Y_{out} as shown. Thus, in this manner, gamma γ is determined continuously in accordance with the relationship as shown by the block diagram of FIG. **1** in a simple and convenient manner utilizing multiplication circuits, combining circuits, logarithm determining circuits, and antilogarithm determining circuits as shown in FIG. **4**. In like manner, the transfer function continuously varied in accordance with the selection of gamma may also be imposed continuously in a simple and convenient manner by circuitry comprising a logarithm determining circuit, combining circuits, multiplication circuit, and an antilogarithm determining circuit. Thus, in this manner localized dynamic contrast enhancement can be provided as a function of dynamic gamma transformation on a pixel-by-pixel basis.

Thus, the system and method of this invention provides for enhancing electronic image data in a manner involving a relatively small number of computations that can be easily calculated in a continuous manner. All of the transfer functions that can be invoked are of a continuous nature without any sharp discontinuities that could otherwise result in undesirable artifacts appearing in the final image. In addition, as previously mentioned, none of the transfer functions operate to clip any portion of the incoming electronic information signal, thus resulting in the entire dynamic range of the incoming signal being transformed.

Other embodiments of the invention including additions, subtractions, deletions and other modifications of the preferred disclosed embodiments of the invention will be obvious to those skilled in the art and are within the scope of the following claims.

What is claimed is:

1. A system for continuously enhancing electronic image data received in a continuous stream of electronic information signals, each signal having a value within a determinate dynamic range of values and corresponding to one of a plurality of succeeding pixels which collectively define an image, said system comprising:

means for averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged; and

means for selecting one of a plurality of different transfer functions for the electronic information signal for each of the succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel and for subsequently transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said selecting and transforming means further operates to select said transfer function as a function of the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal.

2. The system of claim **1** wherein said selecting and transforming means is responsive to an average electronic information signal indicative of low scene light intensity levels for transforming the electronic information signals to provide a higher contrast to those electronic information signals corresponding to pixels having the lowest scene light intensity levels and is further responsive to an average electronic information signal indicative of high scene light intensity levels for transforming the electronic information signals to provide a higher contrast to those electronic information signals corresponding to pixels having the highest scene light intensity levels.

3. The system of claim **2** wherein said selecting and transforming means further operates to select said transfer function as a function of a determined constant whose value corresponds to the amount of contrast provided in those areas of higher contrast provided by said select transfer function.

4. The system of claim **3** wherein said selecting and transforming means further operates to determine the select transfer function as a function of the determination of gamma (γ), said selecting and transforming means including means for determining gamma (γ) in accordance with the relationship

$$\gamma=(1+C)(Av/M-1)$$

where C equals said determined constant, Av equals the average electronic information signal value and M equals a select proportionate value of the dynamic range of the electronic information signals.

5. The system of claim **4** wherein said transforming means transforms the electronic information signal of each pixel in accordance with the relationship

$$Y_{out}=Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$$

where Y_{in} equals the value of the electronic information signal of the pixel to be enhanced, Y_{out} equals the enhanced value of the input electronic information signal and Y_{MAX} equals the highest value of the dynamic range for the electronic information signals.

6. A system for enhancing electronic image data received in a continuous stream of electronic information signals each signal having a value within a determinate dynamic range of values and corresponding to one of a

plurality of succeeding pixels which collectively define an image, said system comprising:

means for averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged;

means for dividing each of the average electronic information signals corresponding to each pixel by a value M corresponding to a select proportionate value of the dynamic range of said electronic information signals;

first means for subtracting 1 from each of the electronic information signals output by said dividing means;

first means for adding a select control parameter and 1;

first means for determining the logarithm of the output from said first adding means;

first means for multiplying the output from said first logarithm determining means by the output from said first subtracting means;

first means for determining the antilogarithm of the output from said first multiplying means;

second means for determining the logarithm for each of the continuous streams of electronic information signals;

second means for subtracting the logarithm for a value corresponding to the maximum value of the electronic information signals from the output of said second logarithm determining means;

second means for multiplying the output of said first antilogarithm determining means by the output from said second subtracting means;

second means for adding the logarithm of the value corresponding to the maximum value of the electronic information signals to the output from said second multiplying means; and

second means for determining the antilogarithm of the output from said second adding means to provide an enhanced output signal value.

7. A method for continuously enhancing electronic image data received in a continuous stream of electronic information signals each signal having a value within a determinate dynamic range of values and corresponding to one of a plurality of succeeding pixels which collectively define an image, said method comprising the steps of:

averaging the electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels;

selecting one of a plurality of different transfer functions for the electronic information signal for each of the plurality of succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel; and

transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said transfer function is selected further as a function of the ratio of the value of the average electronic information signal to a select proportionate value of the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal.

8. The method claim 7 wherein the transfer function is selected: in response to an average electronic information signal indicative of low scene light intensity levels to provide a higher contrast to those electronic information signals corresponding to pixels having the lowest scene light intensity levels and in response to an average electronic information signal indicative of high scene light intensity levels to provide a higher contrast to those electronic information signals corresponding to pixels having the highest scene light intensity levels.

9. The method of claim 8 wherein said transfer function is selected further as a function of a determined constant wherein increasing the value of said constant operates to increase the contrast in those areas of higher contrast provided by said select transfer function.

10. The method of claim 9 wherein said transfer function is selected as a function of the determination of gamma (γ) and gamma (γ) is determined for each pixel in accordance with the relationship

$$\gamma=(1+C)(Av/M-1)$$

where C equals said determined constant, Av equals the average electronic information signal value and M equals said value for one-half the dynamic range of the electronic information signals.

11. The method of claim 10 wherein said select transfer function for the electronic information signal of each pixel comprises the relationship

$$Y_{out}=Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$$

where Y_{in} equals the value of the electronic information signal of the pixel to be enhanced, Y_{out} equals the enhanced value of the input electronic information signal and Y_{MAX} equals the highest value of the dynamic range for the electronic information signals.

12. A method for enhancing electronic image data received in a continuous stream of electronic information signals each signal corresponding to one of a plurality of succeeding pixels which collectively define an image, said method comprising the steps of:

averaging the electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels;

dividing each of the average electronic information signals corresponding to each pixel by a value M corresponding to a select proportionate value of the dynamic range of said electronic information signals;

subtracting 1 from each of the electronic information signals previously divided by the value M to provide a first intermediate signal value;

selecting a control parameter C as a function of the amount of image enhancement to be applied;

adding 1 to the control parameter C;

determining the logarithm of the control parameter C plus 1;

multiplying the logarithm of the control parameter C plus 1 by said first intermediate signal value to provide a second intermediate signal value;

determining the antilogarithm of the second intermediate signal value;

determining the logarithm for each of the continuous streams of electronic information signals;

subtracting from the previously determined logarithm for each of the continuous streams of electronic information signals the logarithm for a value corresponding to the maximum value of the electronic information signals to provide a third intermediate signal value;

multiplying the antilogarithm of the second intermediate signal value by the third intermediate signal value to provide a fourth intermediate signal value;

adding the logarithm of the value corresponding to the maximum value of the electronic information signals to the fourth intermediate signal value to provide a fifth intermediate signal value; and

determining the antilogarithm of the fifth intermediate signal value to provide an enhanced output signal value.

13. The method of claim **12** wherein said image enhancement operates to increase image contrast locally in areas of pixels having low contrast and said control parameter C is determined as a function of the amount of local contrast variation to be provided.

* * * * *

EXHIBIT 2

An Introduction to DIGITAL IMAGE PROCESSING

WAYNE NIBLACK

Prentice/Hall International

Englewood Cliffs, New Jersey London Mexico New Delhi
Rio de Janeiro Singapore Sydney Tokyo Toronto Wellington

Library of Congress Cataloging in Publication Data

Niblack, Wayne
An introduction to digital image processing.

Bibliography: p.
Includes index. 1. Image processing — digital techniques.
I. Title. TA1632.N53 1986 621.36'7 86-5093

ISBN 0-13-480674-3

British Library Cataloguing in Publication Data

Niblack, Wayne
An introduction to digital image processing.
1. Image processing — Digital techniques
I Title
621.38'0414 TA1632

ISBN 0-13-480674-3

First published 1985 by Strandberg Publishing Company.
3460 Birkeroed, Denmark

Prentice-Hall, Inc., *Englewood Cliffs, New Jersey*
Prentice-Hall International (UK) Ltd, *London*
Prentice-Hall of Australia Pty Ltd, *Sydney*
Prentice-Hall Canada Inc., *Toronto*
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Prentice-Hall of India Private Ltd, *New Delhi*
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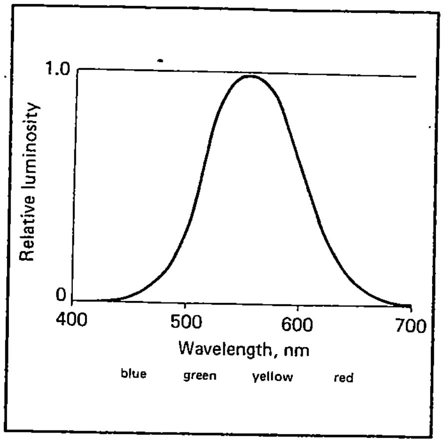
Prentice-Hall of Southeast Asia Pte Ltd, *Singapore*
Editora Prentice-Hall do Brasil Ltda, *Rio de Janeiro*
Whitehall Books Ltd, *Wellington, New Zealand*

Printed and bound in Denmark for
Prentice-Hall International (UK) Ltd,
66 Wood Lane End, Hemel Hempstead, Hertfordshire, HP2 4RG
by Strandberg Bogtryk/Offset a.s., 3460 Birkeroed

1 2 3 4 5 90 89 88 87 86

ISBN 0-13-480674-3



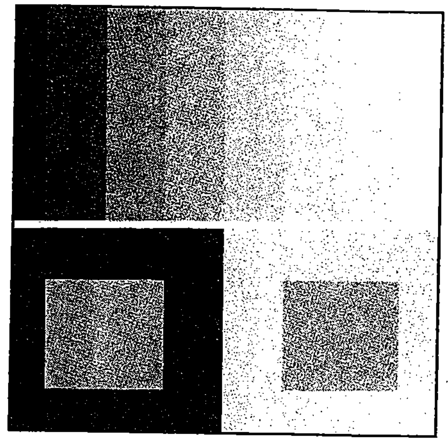


Figure 7. Human perception of brightness: (a) The Relative Luminosity Function V(λ) (Photopic) showing brightness perception as a function of wavelength. (b) Examples of the subjective nature of brightness perception. Top: Near the actual brightness steps, you see apparent bands of lightness or darkness called Mach bands. Bottom: The two center boxes are the same brightness, but the one on the darker background appears brighter. This effect is called simultaneous contrast.

Luminosity Function. A similar curve, the Scotopic Luminostiy Function, is applicable for low light levels, corresponding to "night vision", but the Photopic Luminosity Function is the one applicable for displays used in digital image processing. The function shows that the eye is most sensitive to brightness in the yellow-green. For example, a light radiating a fixed amount of energy in yellow will appear brighter to an observer than a light radiating the same amount of energy in blue. This has implications in digital image processing, for example, in case a multi-colored but uniform brightness display is desired. ?

Definition of Luminance of a Color or Light Source. The Relative Luminosity Function $V(\lambda)$ provides a way of defining the brightness or luminance of a light source of a single wavelength, but it may also be extended to define the luminance of an arbitrary light source. Viewing angle and geometry also affect brightness, but we will assume these are fixed, in which case the luminance of a color with spectral energy distribution $c(\lambda)$, that is, time rate of energy emitted per unit wavelength, is given by:

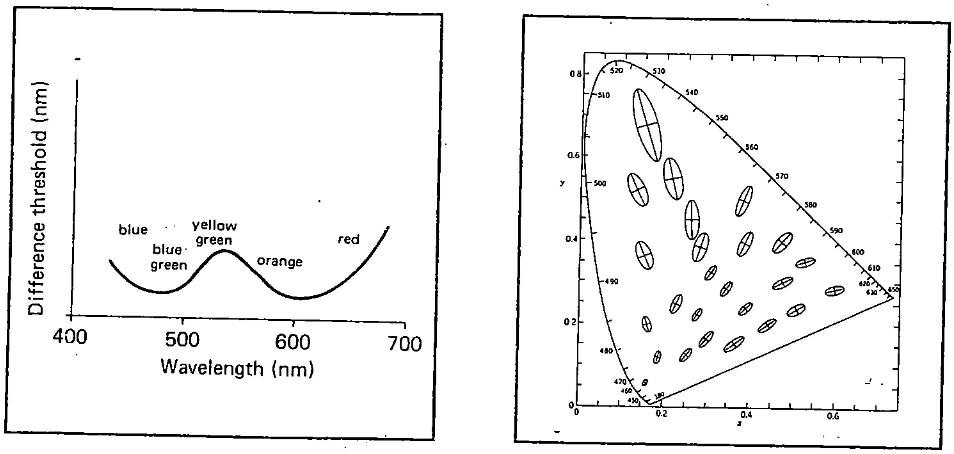


Figure 11. Sensitivity of the eye to chromaticity changes: (a) Wavelength change necessary for a JND for spectral light as a function of wavelength. (b) Ellipses proportional to the change for a JND plotted on a chromaticity diagram. (Part (b) from Wyszecki and Stiles, Color Science, Wiley and Sons, 1967, used by permission.)

2. Chromaticity coordinates: (x,y) coordinates derived from tristimulus coordinates (X,Y,Z) as described previously. To fully specify a color, its luminance Y must be specified in addition to its chromaticity.
3. Perceptual color spaces. These are color spaces based on perceptual parameters such as hue, purity, brilliance, brightness, and saturation. Many different perceptual color spaces have been defined, and a representative form is shown in Figure 12.

Some chromaticity and perceptual color spaces are defined so that the perceptual difference between two colors is given (approximately) by the Euclidean distance between the colors. In this case, the spaces are called uniform color spaces.

Within these three general types of color spaces, many specific spaces may be defined. More than 20 may be found in the literature on color and colorimetry. Some of the standard spaces are:

1. 1931 CIE XYZ and associated (x,y) chromaticities. Tristimulus coordinates X, Y, and Z, or luminance Y and chromaticity coor-

3.0 Filtering

In this chapter we consider techniques for filtering digital images. This includes both low pass (smoothing) and high pass (edge enhancement) filters. The type of filters we discuss are called "enhancement filters" as opposed to "reconstruction filters". A reconstruction filter attempts to restore an image based on some knowledge of the degradation it has undergone, whereas an enhancement filter attempts to improve the quality of an image for human or machine interpretability, where quality is measured subjectively. Most enhancement filters are heuristic and problem oriented, and models of the degradation are generally not used in deriving them.

We begin with an outline of one result from linear systems theory describing linear filters, and this will lead to digital convolution and the moving window operation common in digital image filtering.

3.1 Digital Convolution and Moving Window Operations

Linear systems theory is a branch of mathematics used to describe optical systems and electrical circuits and it provides the mathematical basis for certain filters used in digital image processing. A system S is considered a black box with an input $f(x)$ and output $g(x) = S(f(x))$:

$$f(x) \longrightarrow S \longrightarrow g(x)$$

In our case, $f(x)$ is the original image, represented in one dimension for simplicity, $g(x)$ the filtered output image, and S the filtering operation. The result we want from linear systems theory is that if a

3.3 Smoothing Filters

Smoothing filters are designed to reduce the noise, detail, or "busyness" in an image. If multiple copies of the image are available or can be obtained, they can be averaged pixel by pixel to improve the signal to noise ratio. However, in most cases, only a single image is available. For this case, typical smoothing filters perform some form of moving window operation that may be a convolution or other local computation in the window. It is easy to smooth out an image, but the basic problem of smoothing filters is how to do this without blurring out the interesting features. For this reason, much emphasis in smoothing is on "edge-preserving smoothing", and many of the filters described below were designed for this reason. Typical filters are:

1. Mean. The size and shape of the window over which the mean is computed can be selected. For a 3 x 3 window, the filter weights are:

square window			plus shaped window		
1/9	1/9	1/9		1/5	
1/9	1/9	1/9	1/5	1/5	1/5
1/9	1/9	1/9		1/5	

The square mean filter is separable. Let M be the 3 x 3 square window kernel above and let $m_v = m_h = (1/3 \;\; 1/3 \;\; 1/3)^T$ Then M is given by:

$$M = m_v m_h^T = \begin{pmatrix} 1/3 \\ 1/3 \\ 1/3 \end{pmatrix} (1/3 \;\; 1/3 \;\; 1/3)$$

2. Weighted mean. A weighted mean is often used in which the weight for a pixel is related to its distance from the center point. For 3 x 3 windows, the weights may be:

square window			plus shaped window		
1/16	1/8	1/16		1/6	
1/8	1/4	1/8	1/6	1/3	1/6
1/16	1/8	1/16		1/6	

The square weighted mean window is also separable, with $w_v = w_h = (1/4 \ \ 1/2 \ \ 1/4)^T$.

3. Mode. A pixel is replaced by its most common neighbor. This is particularly useful in coded images such as classification maps (see chapter "Classification" on page 167) in which the pixel values represent object labels. Averaging labels makes no sense (what is the average of "rib" and "lung"?), but mode filters may clean up isolated points.
4. Median. A pixel value is replaced by the median of its neighbors. The median of a set of numbers is the value such that 50% are above and 50% are below. Conceptually simple, the median filter is somewhat awkward to implement because of the pixel value sorting required. However, it is one of the better edge preserving smoothing filters.
5. k nearest neighbor. Set $v(i, j)$ to the average of the k pixels in $n(i, j)$ whose values are closest to that of $v(i, j)$. A typical value of k is 6 when $n(i, j)$ is the 3 x 3 square window centered on (i, j). This is another filter used in edge preserving smoothing.
6. The Sigma filter [15]. Set $v(i, j)$ equal to the average of all pixels in its neighborhood whose value is within t counts of the value of $v(i, j)$. t is an adjustable parameter. This is called the Sigma filter because the parameter t may be derived from the sigma, or standard deviation, of the pixel value distribution. This filter is similar to the k nearest neighbor filter.
7. Filters based on pixel values and gradients.

Example 1: Inverse Gradient Filter [21]. Compute $v_{out}(i, j)$ as:

$$v_{out}(i, j) = \frac{1}{2} v_{in}(i, j) + \frac{1}{2}\left(\sum_{k,l \in n8} w(k,l)\, v_{in}(k,l)\right)$$

where the $w(k,l)$ are inversely proportional to $|v_{in}(i, j) - v_{in}(k,l)|$ and $n_8(i, j)$ is the neighborhood of eight pixels immediately surrounding (i, j). That is, neighboring pixels are included in the average with a weight inversely proportional to their pixel value difference (gradient) from the central pixel.

Example 2: Let p be the pixel at (i, j). For the gradient $|(x + x + x) - (y + y + y)|$ computed for the four sets of x and y shown:

$$\begin{array}{cccc} xx & xxx & xx & y\ x \\ xpy & p & ypx & ypx \\ yy & yyy & yy & y\ x \end{array}$$

set v_{out} to the average of the xs and ys with the minimum gradient.

Example 3: Compute a horizontal and vertical gradient (for example, the second and fourth gradients of the preceding example), and set $v_{out}(i, j)$ to the average of:

v(i,j)
+ (v(i,j)'s horizontal neighbors if the horizontal gradient is less than some threshold)
+ (v(i,j)'s vertical neighbors if the vertical gradient is less than the threshold).

8. Maximum homogeneity filters. These are of the form:
   a. Determine the neighborhood of (i, j) most similar to v_{in}.
   b. Apply some smoothing using only points from this neighborhood.

   The idea is to smooth within homogeneous areas, but not to include pixels from other populations in the smoothing.

Example 1: For the 5 neighborhoods surrounding the central pixel p given by:

$$\begin{array}{ccccc} xxx & xxx & xxp & xxx & xxx \\ xxx & xxx & xxx & xxx & xpx \\ xxp & pxx & xxx & xxp & xxx \end{array}$$

replace the value v_{in} of p with the neighborhood average closest to v_{in}.

Example 2: [17] For the 9 neighborhoods

$$\begin{array}{ccccccccc} xx & xxx & xx & xx & px & p & xp & xx & xxx \\ xxx & xxx & xxx & pxx & xxx & xxx & xxx & xxp & xpx \\ xp & p & px & xx & xx & xxx & xx & xx & xxx \end{array}$$

replace v_{in} with the average of the neighborhood whose standard deviation is minimum. (The neighborhoods include the central pixel p.)

9. Filters of the form:

If (some condition)
  Apply filter method 1
Else
  Apply filter method 2
Endif

The objective is to perform one type of smoothing for noise pixels, and another for the others. A pixel is considered noise if it is significantly different from its neighbors. An example is:

If $|v(i,j) - \overline{v(i,j)}| >$ *threshold*
  $v(i,j) = \overline{v(i,j)}$
Else
  Leave $v(i,j)$ *unchanged*
Endif

10. Filters that fit a surface s through a neighborhood of (i, j) and replace v_{in} with $s(i, j)$. For $s(i, j) = k$, the surface is a horizontal plane, and the filter is equivalent to the mean filter. Including other terms in s such as $s(i, j) = s_0 + s_1 i + s_2 j$ fits tilted planes or higher order surfaces.
11. Closest of minimum and maximum [14]. A filter defined by computing the minimum and maximum in $n(i, j)$ and setting $v_{out}(i, j)$ to the one that is closest in value to $v_{in}(i, j)$ often produces good results by sharpening the boundaries between classes. The filter is typically iterated. It leaves isolated spikes which may need to be removed by another filter, say a medain filter, mixed into the iterations.
12. "Superspike." The superspike algorithm [18] performs a local averaging at each pixel, but uses the global image histogram to select the pixels to include in the averaging. Neighbors are included in the average only if (1) the neighbor's value is more probable than the central pixel based on the image histogram, and (2) there is no concavity in the histogram between the pixel's value and the neighbor's value. The idea is to favor the frequently occurring pixel values, assuming they represent the real objects in an image, and suppress the other values, assuming they are noise or boundary/transition pixels. The second condition is intended to include only pixels from the same category in the averaging. The algorithm is iterated, and tends to result in a histogram made up of a relative few sharp spikes.

Notice that some of the filters are defined to be iterated, and all of them can be iterated to further the smoothing. Some example results are shown in Figure 40, and a quantitative comparison of several of them is described in [12].

3.4 Edge Enhancement Filters and Edge Detection

Edge enhancement filters are the opposite of smoothing filters. Whereas smoothing filters are low pass filters, edge enhancement filters are high pass filters and their effect is to enhance or boost edges. The term "edge detector" is also used. This may mean a simple high

EXHIBIT 3

EXHIBIT 3: POLAROID'S PROPOSED CONSTRUCTIONS

Claim Terms of the '381 Patent	**Polaroid's Construction**
The preamble of claim 1 "A system for continuously enhancing electronic image data received in a continuous stream of electronic information signals, each signal having a value within a determinate dynamic range of values and corresponding to one of a plurality of succeeding pixels which collectively define an image, said system comprising:"	The preamble of claim 1 is not a limitation because it merely states the purpose or intended use of the invention set out in the claim body.
"means for averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged" [Claim 1]	This claim element is a means-plus-function element. **Function** – "averaging electronic information signals corresponding to selected pluralities of pixels and providing an average electronic information signal for each said plurality of pixels so averaged." **Terms used to describe the function should be construed as:** *"averaging"* should be construed to mean "calculating an intermediate value for" "*average*" should be construed to mean "of calculated intermediate value" *"electronic information signals"* should be construed to mean "signals providing pixel information, such as color, luminance, or chrominance values" *"average electronic information signal"* should be construed to mean "signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value." **Structure** – a low pass filter or block average and equivalents thereof.

Claim Terms of the '381 Patent	Polaroid's Construction
"means for selecting one of a plurality of different transfer functions for the electronic information signal for each of the succeeding pixels whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel and for subsequently transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said selecting and transforming means further operates to select said transfer function as a function of the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal" [Claim 1]	This claim element is a means-plus-function element. **Function** – "selecting one of a plurality of different transfer functions for the electronic information signal for each of the succeeding pixels whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel and for subsequently transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said selecting and transforming means further operates to select said transfer function as a function of the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal." **Terms used to describe the function should be construed as**: *"transfer function"* should be construed to mean function that transforms an input signal. *"electronic information signal"* should be construed to mean "signal providing pixel information, such as a color, luminance, or chrominance value" *"ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals"* should be construed as "ratio of that calculated intermediate value over a value that lies within the range of possible values" *"average electronic information signal"* should be construed to mean "signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value" **Structure** – $Y_{out} = Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$, where $\gamma = (1 + C)^{(Av/M - 1)}$, where Y_{out} is the transformed signal providing pixel information, such as a color, luminance, or chrominance value, Y_{MAX} is the highest value of the dynamic range, Y_{in} is the input signal providing pixel information, such as a color, luminance, or chrominance value, C is a chosen number, Av is a calculated intermediate value, and M is any value within the dynamic range, and

Claim Terms of the '381 Patent	**Polaroid's Construction**
"electronic information signals" [Claims 1, 2, 7, 8]	"signals providing pixel information, such as color, luminance, or chrominance values"
"average" [Claims 1, 2, 7, 8]	"of calculated intermediate value"
"average electronic information signal" [Claims 1, 2, 7, 8]	"signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value"
"wherein said selecting and transforming means further operates to select said transfer function as a function of a determined constant whose value corresponds to the amount of contrast provided in those areas of higher contrast provided by said select transfer function." [Claim 3]	This claim element is a means-plus-function element. **Function** – "selecting one of a plurality of different transfer functions for the electronic information signal for each of the succeeding pixels and for subsequently transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said selecting and transforming means further operates to select said transfer function as a function of the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal, said selecting and transforming means further operates to select said transfer function as a function of a determined constant whose value corresponds to the amount of contrast provided in those areas of higher contrast provided by said select transfer function." **Structure** – $Y_{out} = Y_{MAX}(Y_{in}/Y_{MAX})^{\gamma}$, where $\gamma = (1 + C)^{(Av/M - 1)}$, where Y_{out} is the transformed signal providing pixel information, such as a color, luminance, or chrominance value, Y_{MAX} is the highest value of the dynamic range, Y_{in} is the input signal providing pixel information, such as a color, luminance, or chrominance value, C is a chosen number, Av is a calculated intermediate value, and M is any value within the dynamic range, and equivalents thereof. The structure associated with this additional function is the chosen number, C and equivalents thereof.

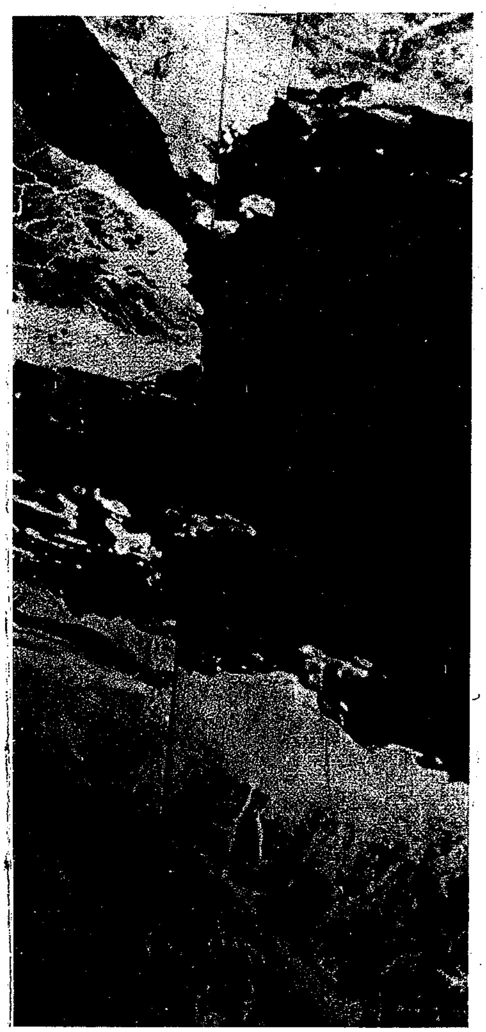
Claim Terms of the '381 Patent	**Polaroid's Construction**
The preamble of claim 7 "A method for continuously enhancing electronic image data received in a continuous stream of electronic information signals, each signal having a value within a determinate dynamic range of values and corresponding to one of a plurality of succeeding pixels which collectively define an image, said method comprising the steps of:"	The preamble of claim 7 is not a limitation because it merely states the purpose or intended use of the invention set out in the claim body.
"averaging" [Claim 7]	"calculating an intermediate value for"
"selecting one of a plurality of different transfer functions for the electronic information signal for each of the plurality of succeeding pixels in a manner whereby each transfer function is selected as a function of the electronic information signal for one pixel and the average electronic information signal for the select plurality of pixels containing said one pixel" [Claim 7]	"selecting one of a plurality of different functions that transform an input signal for the signal providing pixel information, such as a color, luminance, or chrominance value for each of the plurality of succeeding pixels in a manner whereby each function that transforms an input signal is selected as a function of the signal providing pixel information, such as a color, luminance, or chrominance value for one pixel and the signal providing pixel information such as a color, luminance, or chrominance value of calculated intermediate value for the select plurality of pixels containing said one pixel"
"select proportionate value of the dynamic range" [Claim 7]	"value within the range of possible values "
"transforming the electronic information signal corresponding to each pixel by the transfer function selected for that pixel wherein said transfer function is selected further as a function of the ratio of the value of the average electronic information signal to the dynamic range of the electronic information signals such that the ratio increases in correspondence with the increase in the value of the average electronic information signal" [Claim 7]	"transforming the signal providing pixel information, such as a color, luminance, or chrominance value corresponding to each pixel by the function that transforms an input signal selected for that pixel wherein said function that transforms an input signal is selected further as a function of the ratio of value of the signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value to a value within the range of possible values such that the ratio increases in correspondence with the increase in the value of the signal providing pixel information, such as a color, luminance, or chrominance value of calculated intermediate value"

Claim Terms of the ’381 Patent	**Polaroid’s Construction**
“determined constant” [Claim 9]	No construction is required and the limitation is ***not*** limited to a control parameter.

EXHIBIT 4

McGraw-Hill DICTIONARY OF SCIENTIFIC AND TECHNICAL TERMS

Fourth Edition



Sybil P. Parker
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On the cover: Pattern produced from white light by a computer-generated diffraction plate containing 529 square apertures arranged in a 23 × 23 array. (R. B. Hoover, Marshall Space Flight Center)

On the title pages: Aerial photograph of the Sinai Peninsula made by Gemini spacecraft. (NASA)

In addition, material has been drawn from the following references: R. E. Huschke, *Glossary of Meteorology*, American Meteorological Society, 1959; *U.S. Air Force Glossary of Standardized Terms*, AF Manual 11-1, vol. 1, 1972; *Communications-Electronics Terminology*, AF Manual 11-1, vol. 3, 1970; W. H. Allen, ed., *Dictionary of Technical Terms for Aerospace Use*, 1st ed., National Aeronautics and Space Administration, 1965; J. M. Gilliland, *Solar-Terrestrial Physics: A Glossary of Terms and Abbreviations*, Royal Aircraft Establishment Technical Report 67158, 1967; *Glossary of Air Traffic Control Terms*, Federal Aviation Agency; *A Glossary of Range Terminology, White Sands Missile Range, New Mexico*, National Bureau of Standards, AD 467-424; *A DOD Glossary of Mapping, Charting and Geodetic Terms*, 1st ed., Department of Defense, 1967; P. W. Thrush, comp. and ed., *A Dictionary of Mining, Mineral, and Related Terms*, Bureau of Mines, 1968; *Nuclear Terms: A Glossary*, 2d ed., Atomic Energy Commission; F. Casey, ed., *Compilation of Terms in Information Sciences Technology*, Federal Council for Science and Technology, 1970; *Glossary of Stinfo Terminology*, Office of Aerospace Research, U.S. Air Force, 1963; *Naval Dictionary of Electronic, Technical, and Imperative Terms*, Bureau of Naval Personnel, 1962; *ADP Glossary*, Department of the Navy, NAVSO P-3097.

McGRAW-HILL DICTIONARY OF SCIENTIFIC AND TECHNICAL TERMS, Fourth Edition

1 2 3 4 5 6 7 8 9 0 DOW/DOW 8 9 5 4 3 2 1 0 9

ISBN 0-07-045270-9

Library of Congress Cataloging-in-Publication Data

McGraw-Hill dictionary of scientific and technical terms.

1. Science—Dictionaries. 2. Technology—Dictionaries.
I. Parker, Sybil P.
Q123.M34 1989 503'.21 88-13490
ISBN 0-07-045270-9

detector balanced bias [ELECTR] Controlling circuit used in radar systems for anticlutter purposes. { di'tek·tər ¦bal·ənst 'bī·əs }

detector bar [CIV ENG] A device that keeps a railroad switch locked while a train is passing over it. { di'tek·tər ˌbär }

detector car [ENG] A railroad car used to detect flaws in rails. { di'tek·tər ˌkär }

detent [MECH ENG] A catch or lever in a mechanism which initiates or locks movement of a part, especially in escapement mechanisms. { 'dēˌtent }

detention basin [CIV ENG] A reservoir without control gates for storing water over brief periods of time until the stream has the capacity for ordinary flow plus released water; used for flood regulation. { di'ten·chən ˌbā·sən }

detergent [MATER] A synthetic cleansing agent resembling soap in the ability to emulsify oil and hold dirt, and containing surfactants which do not precipitate in hard water; may also contain protease enzymes and whitening agents. { di'tər·jənt }

detergent additive [MATER] A substance incorporated in lubricating oils which gives them the property of keeping insoluble material in suspension. { di'tər·jənt ˌad·ə·tiv }

detergent alkylate *See* dodecylbenzene. { di'tər·jənt 'al·kəˌlāt }

detergent oil [MATER] A lubricating oil with special sludge-dispersing properties for use in internal combustion engines. { di'tər·jənt ˌȯil }

deteriorating supplies [ORD] Those items that may reasonably be expected to become unusable within 1 or 2 years, whether used or not. { di'tir·ē·əˌrād·iŋ sə'plīz }

deterioration [ENG] Decline in the quality of equipment or structures over a period of time due to the chemical or physical action of the environment. { diˌtir·ē·ə'rā·shən }

determinant [CONT SYS] The product of the partial return differences associated with the nodes of a signal-flow graph. [MATH] A certain real-valued function of the column vectors of a square matrix which is zero if and only if the matrix is singular; used to solve systems of linear equations and to study linear transformations. { də'tər·mə·nənt }

determinant tensor [MATH] A tensor whose components are each equal to the corresponding component of the Levi-Civita tensor density times the square root of the determinant of the metric tensor, and whose contravariant components are each equal to the corresponding component of the Levi-Civita density divided by the square root of the metric tensor. Also known as permutation tensor. { də'tər·mə·nənt 'ten·sər }

determinate [SCI TECH] Bounded by definite limits. { də'tər·mə·nət }

determinate cleavage [EMBRYO] A type of cleavage which separates portions of the zygote with specific and distinct potencies for development as specific parts of the body. { də'tər·mə·nət 'klē·vij }

determinate growth [BOT] Growth in which the axis, or central stem, being limited by the development of the floral reproductive structure, does not grow or lengthen indefinitely. { də'tər·mə·nət 'grōth }

determinate structure [MECH] A structure in which the equations of statics alone are sufficient to determine the stresses and reactions. { də'tər·mə·nət 'strək·chər }

determination [ANALY CHEM] The finding of the value of a chemical or physical property of a compound, such as reaction-rate determination or specific-gravity determination. { dəˌtər·mə'nā·shən }

determinism *See* causality. { də'tər·məˌniz·əm }

deterministic algorithm *See* static algorithm. { dəˌtər·mə'nis·tik 'al·gəˌrith·əm }

deterministic equation [PHYS] An equation that governs the motion of a dynamical system and does not contain terms corresponding to random forces. { diˌtər·mə'nis·tik i'kwā·zhən }

detonating agent [MATER] An explosive, such as PETN, contained in the blasting cap or detonator. { 'det·ənˌād·iŋ ˌā·jənt }

detonating fuse [ENG] A device consisting of a core of high explosive within a waterproof textile covering and set off by an electrical blasting cap fired from a distance by means of a fuse line; used in large, deep boreholes. { 'detˌənˌād·iŋ 'fyüz }

detonating net [ORD] Network of detonating cord that is interlaced in a mesh design; used for clearing paths through mine fields by exploding the mines over which the nets are placed and detonated. { 'det·ənˌād·iŋ ˌnet }

detonating primer [MATER] A primer used to fire high explosives that is exploded by a fuse. { 'det·ənˌād·iŋ 'prīm·ər }

detonating rate [MECH] The velocity at which the explosion wave passes through a cylindrical charge. { 'det·ənˌād·iŋ ˌrāt }

detonating relay [ENG] A device used in conjunction with the detonating fuse to avoid short-delay blasting. { 'det·ənˌād·iŋ ˌrēˌlā }

detonation [CHEM] An exothermic chemical reaction that propagates with such rapidity that the rate of advance of the reaction zone into the unreacted material exceeds the velocity of sound in the unreacted material; that is, the advancing reaction zone is preceded by a shock wave. [MECH ENG] Spontaneous combustion of the compressed charge after passage of the spark in an internal combustion engine; it is accompanied by knock. { ˌdet·ən'ā·shən }

detonation flame spraying [MET] A flame-spraying method in which the combined mixture of fuel gas, oxygen, and powdered coating liquefies and explodes the material to the workpiece. { ˌdet·ən'ā·shən 'flām ˌsprā·iŋ }

detonation front [ENG] The reaction zone of a detonation. { ˌdet·ən'ā·shən ˌfrənt }

detonation wave [FL MECH] A shock wave that accompanies detonation and has a shock front followed by a region of decreasing pressure in which the reaction occurs. { ˌdet·ən'ā·shən ˌwāv }

detonator [ENG] A device, such as a blasting cap, employing a sensitive primary explosive to detonate a high-explosive charge. { 'det·ənˌād·ər }

detonator safety [ENG] A fuse has detonator safety or is detonator safe when the functioning of the detonator cannot initiate subsequent explosive train components. { 'det·ənˌād·ər ˌsāf·tē }

detonics [ENG] The study of detonating and explosives performance. { de'tän·iks }

detorsion [INV ZOO] Untwisting of the 180° visceral twist imposed by embryonic torsion on many gastropod mollusks. [MED] Untwisting of an abnormal torsion, as of a ureter or intestine. { dē'tȯr·shən }

detoxification [BIOCHEM] The act or process of removing a poison or the toxic properties of a substance in the body. { dēˌtäk·sə·fə'kā·shən }

detrainment [METEOROL] The transfer of air from an organized air current to the surrounding atmosphere. { dē'trān·mənt }

detrital fan *See* alluvial fan. { də'trīd·əl 'fan }

detrital minerals [MINERAL] Grains of heavy minerals found in sediment, resulting from mechanical disintegration of the parent rock. { də'trīd·əl 'min·rəlz }

detrital ratio *See* clastic ratio. { də'trīd·əl 'rā·shō }

detrital remanent magnetization [GEOPHYS] Magnetization acquired by magnetic grains during formation of a sedimentary rock. Abbreviated DRM. { də'trīd·əl 'rem·ə·nənt 'mag·nəd·ə'zā·shən }

detrital reservoir [GEOL] A clastic or detrital-granular reservoir, classified by rock type and other factors such as sediments (quartzose-type, graywacke, or arkose sediments). { də'trīd·əl 'rez·əvˌwär }

detrital sediment [GEOL] Accumulations of the organic and inorganic fragmental products of the weathering and erosion of land transported to the place of deposition. { də'trīd·əl 'sed·ə·mənt }

detritus [GEOL] Any loose material removed directly from rocks and minerals by mechanical means, such as disintegration or abrasion. { də'trīd·əs }

detritus feeder *See* deposit feeder. { də'trīd·əs 'fēd·ər }

detritus tank [CIV ENG] A tank in which heavy suspended matter is removed in sewage treatment. { də'trīd·əs ˌtaŋk }

detrivorous [BIOL] Referring to an organism that feeds on dead animals or partially decomposed organic matter. { də'triv·ə·rəs }

Detroit rocking furnace [ENG] An indirect arc type of rocking furnace having graphite electrodes entering horizontally from opposite ends. { də'trȯit 'räk·iŋ 'fər·nəs }

detune [ELECTR] To change the inductance or capacitance of a tuned circuit so its resonant frequency is different from the incoming signal frequency. { dē'tün }

detuning stub [ELECTROMAG] Quarter-wave stub used to

EXHIBIT 5

THE RANDOM HOUSE DICTIONARY OF THE ENGLISH LANGUAGE

Second Edition

Unabridged

Dedicated to the memory of
Jess Stein

All inquiries should be addressed to Reference Department, Random House, Inc., 201 E. 50th Street, New York, N.Y. 10022.
Published in the United States by Random House, Inc., and simultaneously in Canada by Random House of Canada Limited, Toronto

Library of Congress Cataloging-in-Publication Data
The Random House dictionary of the English language.
(Random House dictionaries)
1. English language—Dictionaries. I. Flexner,
Stuart Berg. II. Series.
PE1625.R3 1987 423 87-4500
ISBN 0-394-50050-4; 0-394-56500-2 deluxe ed.

Manufactured in the United States of America

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Aux Cayes (ō kā′), former name of **Les Cayes.**

aux•e•sis (ôg zē′sis, ôk sē′-), *n. Biol.* growth, esp. that resulting from an increase in cell size. Cf. **merisis.** [1570–80; < Gk: increase, equiv. to *auxē-* verbid s. of *aúxein* to increase + *-sis* -SIS]

aux•et•ic (ôg zet′ik, ôk set′-), *Biol.* —*adj.* **1.** pertaining to or promoting auxesis. —*n.* **2.** an auxetic agent. [1730–40; < Gk *auxētikos* increasing, equiv. to *auxēt(ós)* increased (deriv. of *aúxein;* see AUXESIS) + *-ikos* -IC]

aux•il•ia•ry (ôg zil′yə rē, -zil′ə-), *adj., n., pl.* **-ries.** —*adj.* **1.** additional; supplementary; reserve: *an auxiliary police force.* **2.** used as a substitute or reserve in case of need: *The hospital has an auxiliary power system in case of a blackout.* **3.** (of a boat) having an engine that can be used to supplement the sails: *an auxiliary yawl.* **4.** giving support; serving as an aid; helpful: *The mind and emotions are auxiliary to each other. Passion is auxiliary to art.* —*n.* **5.** a person or thing that gives aid of any kind; helper. **6.** an organization allied with, but subsidiary to, a main body of restricted membership, esp. one composed of members' relatives: *The men's club and the ladies' auxiliary were merged into one organization.* **7.** See **auxiliary verb. 8. auxiliaries,** foreign troops in the service of a nation at war. **9.** *Navy.* a naval vessel designed for other than combat purposes, as a tug, supply ship, or transport. **10.** *Naut.* a sailing vessel carrying an auxiliary propulsion engine or engines. [1595–1605; < L *auxiliārius* assisting, aiding, helping, equiv. to *auxili(um)* aid, help (*aux(us)* increased, augmented (ptp. of *augēre: aug-* increase + *-sus,* var. of *-tus* ptp. suffix) + *-ilium* n. suffix) + *-ārius* -ARY]
—**Syn. 2.** backup, ancillary, secondary. **5.** aide, ally, assistant; help.

auxil′iary equa′tion, *Math.* See **characteristic equation** (def. 1b.).

auxil′iary lan′guage, a language, as Esperanto, Swahili, or English, used for intercommunication by speakers of various other languages. [1900–05]

auxil′iary raft′er, 1. a rafter reinforcing a principal rafter. **2.** a rafter reinforcing a diagonal member of a queen post truss. Also called **cushion rafter.**

auxil′iary stor′age, *Computers.* See **secondary storage.** Also called **auxil′iary mem′ory.**

auxil′iary tone′, *Music.* a melodic ornamental tone following a principal tone by a step above or below and returning to the principal tone; embellishment. Also called **auxil′iary note′.**

auxil′iary verb′, a word used in construction with and preceding certain forms of other verbs, as infinitives or participles, to express distinctions of tense, aspect, mood, etc., as *did* in *Did you go?, am* in *I am listening, have* in *We have spoken,* or *can* in *They can see.* Also called **helping verb.** [1755–65]

aux•i•lyt•ic (ôk′sə lit′ik), *adj. Biochem.* promoting lysis or increasing lytic action. [AUX- + -I- + -LYTIC]

aux•in (ôk′sin), *n. Biochem.* a class of substances that in minute amounts regulate or modify the growth of plants, esp. root formation, bud growth, and fruit and leaf drop. [1930–35; AUX- + -IN²] —**aux•in′ic,** *adj.*

Aux•o (ôk′sō), *n. Class. Myth.* one of the Graces worshiped at Athens.

auxo-, a combining form meaning "growth," "increase," used in the formation of compound words: *auxochrome.* Also, esp. *before a vowel,* **aux-.** [< Gk *aúx(ein)* to grow, increase (var. of *auxánein*) + -O-]

aux•o•car•di•a (ôk′sə kär′dē ə), *n. Pathol.* enlargement of the heart, as by hypertrophy or dilatation. [AUXO- + -CARDIA]

aux•o•chrome (ôk′sə krōm′), *n. Chem.* any radical or group of atoms that intensifies the color of a substance. [1890–95; AUXO- + CHROME] —**aux′o•chrom′ic,** *adj.*

aux•o•troph (ôk′sə trof′, -trōf′), *n. Biol.* a mutant organism, esp. a microorganism, that has a nutritional requirement not shared by the parent organism. Cf. **prototroph** (def. 1). [1950–55; back formation from *auxotrophic;* see AUXO-, TROPHIC] —**aux′o•troph′ic,** *adj.*

Av (äv, ôv), *n.* the eleventh month of the Jewish calendar. Also, **Ab.** Cf. **Jewish calendar.** [< Heb *ābh*]

AV, 1. arteriovenous. **2.** atrioventricular. **3.** audiovisual.

av., 1. avenue. **2.** average. **3.** See **avoirdupois weight.**

A-V, 1. atrioventricular. **2.** audiovisual.

A/V, 1. Also, **a.v.** ad valorem. **2.** audiovisual.

A.V., 1. Artillery Volunteers. **2.** audiovisual. **3.** Authorized Version (of the Bible).

a•va (ə vä′, ə vô′), *adv. Scot.* of all; at all. Also, **a•va′.**

A•va (ā′və), *n.* a female given name.

av•a•da•vat (av′ə də vat′), *n.* a waxbill, *Estrilda amandava,* native to Asia, having in the male scarlet plumage with white dots on the sides and breast: raised as a cage bird. Also, **amadavat.** [1770–80; earlier *amaduvad,* after *Amidavad,* a 17th century name (perh. < Pg) for AHMEDABAD, in Gujarat, from where the birds were first exported]

a•vail (ə vāl′), *v.t.* **1.** to be of use or value to; profit; advantage: *All our efforts availed us little in trying to effect a change.* —*v.i.* **2.** to be of use; have force or efficacy; serve; help: *His strength did not avail against the hostile onslaught.* **3.** to be of value or profit. **4. avail oneself of,** to use to one's advantage: *They availed themselves of the opportunity to hear a free concert.* —*n.* **5.** advantage; use; efficacy; effective use in the achievement of a goal or objective: *His belated help will be of little or no avail.* **6. avails,** *Archaic.* profits or proceeds. [1250–1300; ME *availe,* equiv. to *a-* A-² + *vaile* < OF *vail-* (s. of *valoir*) < L *valēre* to be of worth] —**a•vail′ing•ly,** *adv.*

a•vail•a•ble (ə vā′lə bəl), *adj.* **1.** suitable or ready for use; of use or service; at hand: *I used whatever tools were available.* **2.** readily obtainable; accessible: *available resources.* **3.** having sufficient power or efficacy; valid. **4.** *Archaic.* efficacious; profitable; advantageous. [1425–75; late ME; see AVAIL, -ABLE] —**a•vail′a•bil′i•ty, a•vail′a•ble•ness,** *n.* —**a•vail′a•bly,** *adv.*
—**Syn. 1.** accessible, usable, handy. —**Ant. 1.** unavailable.

avail′able light′, *Photog., Fine Arts.* the natural or usual light on a subject.

av•a•lanche (av′ə lanch′, -länch′), *n., v.,* **-lanched, -lanch•ing.** —*n.* **1.** a large mass of snow, ice, etc., detached from a mountain slope and sliding or falling suddenly downward. **2.** anything like an avalanche in suddenness and overwhelming quantity: *an avalanche of misfortunes; an avalanche of fan mail.* **3.** Also called **Townsend avalanche.** *Physics, Chem.* a cumulative ionization process in which the ions and electrons of one generation undergo collisions that produce a greater number of ions and electrons in succeeding generations. —*v.i.* **4.** to come down in, or like, an avalanche. —*v.t.* **5.** to overwhelm with an extremely large amount of anything; swamp. [1755–65; < F < dial. (Savoy) *avalantse,* alter. (by assoc. with *avaler* to descend rapidly) of *laventse* < pre-L (perh. Ligurian) **lavanca,* or reshaping of LL *labina* landslide (deriv. of L *labi* to slide) with a pre-L suffix *-anca*]

av′alanche lil′y, either of two plants, *Erythronium grandiflorum* or *E. montanum,* of the lily family, of the mountains of northwestern North America, having nodding yellow or white flowers. [1910–15, *Amer.;* appar. so called because it is found near the snow line or the edge of glaciers]

av′alanche wind′ (wind), the wind that is created in front of an avalanche.

A•va•lo•ki•te•sva•ra (uv′ə lō′ki tāsh′vər ə), *n. Buddhism.* a male Bodhisattva, widely revered and identified with various persons and gods. Cf. **Kwan-Yin.**

Av•a•lon (av′ə lon′), *n. Celtic Legend.* an island, represented as an earthly paradise in the western seas, to which King Arthur and other heroes were carried at death. Also, **Av′al•lon′.** [< ML *(insula) avallonis* (Geoffrey of Monmouth) (island) of Avallon, lit., apple tree (island) < a British Celt s. for apple tree, c. Welsh *afall* (pl. collective), Middle Breton *avallenn* (sing.), OIr *aball* (fem.) < **ǝbǝl-n-,* c. Slavic **(j)ablanĭ;* see APPLE]

Av′alon Penin′sula, a peninsula in SE Newfoundland, in E Canada: surrounded on three sides by the Atlantic Ocean. ab. 3579 sq. mi. (9270 sq. km).

a•vant-garde (ə vänt′gärd′, ə vant′-, av′änt-, ä′vänt-; *Fr.* A VÄN GARD′), *n.* **1.** the advance group in any field, esp. in the visual, literary, or musical arts, whose works are characterized chiefly by unorthodox and experimental methods. —*adj.* **2.** of or pertaining to the experimental treatment of artistic, musical, or literary material. **3.** belonging to the avant-garde: *an avant-garde composer.* **4.** unorthodox or daring; radical. [1475–85; in sense "vanguard"; < F: lit., fore-guard. See VANGUARD] —**a•vant′-gard′ist,** *n.*

a•vant-gard•ism (ə vänt′gär′diz əm, ə vant′-, av′-änt-, ä′vänt-), *n.* the attitudes, techniques, etc., of the cultural avant-garde. [1945–50; AVANT-GARDE + -ISM]

A•van•ti (ə vun′tē), *n.* **Kingdom of,** an ancient Aryan kingdom of W central India, with its capital near modern Ujjain; flourished in the 6th–4th centuries B.C.

A•var (ä′vär), *n.* a member of a people, probably originating in Asia, who settled in Dacia A.D. c555, later occupied Pannonia, and invaded other parts of central and eastern Europe before their decline in the 9th century.

av•a•rice (av′ər is), *n.* insatiable greed for riches; inordinate, miserly desire to gain and hoard wealth. [1250–1300; ME < OF < L *avāritia,* equiv. to *avār(us)* greedy + *-itia* -ICE]
—**Syn.** cupidity.

av•a•ri•cious (av′ə rish′əs), *adj.* characterized by avarice; greedy; covetous. [1425–75; late ME; see AVARICE, -IOUS] —**av′a•ri′cious•ly,** *adv.* —**av′a•ri′cious•ness,** *n.*
—**Syn.** AVARICIOUS, COVETOUS, GREEDY, RAPACIOUS share the sense of desiring to possess more of something than one already has or might in normal circumstances be entitled to. AVARICIOUS often implies a pathological, driven greediness for money or other valuables and usually suggests a concomitant miserliness: *the cheerless dwelling of an avaricious usurer.* COVETOUS implies a powerful and usually illicit desire for the property or possessions of another: *The book collector was openly covetous of my rare first edition.* GREEDY, the most general of these terms, suggests a naked and uncontrolled desire for almost anything—food and drink, money, emotional gratification: *embarrassingly greedy for praise.* RAPACIOUS, stronger and more assertive than the other terms, implies an aggressive, predatory, insatiable, and unprincipled desire for possessions and power: *a rapacious frequenter of tax sales and forced auctions.*

a•vast (ə vast′, ə väst′), *imperative verb. Naut.* (used as a command to stop or cease): *Avast heaving!* [1675–85; perh. < D *houd vast* hold fast (see HOLD¹, FAST¹)]

av•a•tar (av′ə tär′, av′ə tär′), *n.* **1.** *Hindu Myth.* the descent of a deity to the earth in an incarnate form or some manifest shape; the incarnation of a god. **2.** an embodiment or personification, as of a principle, attitude, or view of life. [1775–85; < Skt *avatāra* a passing down, equiv. to *ava* down + *-tāra* a passing over]

a•vaunt (ə vônt′, ə vänt′), *adv. Archaic.* away; hence. [1275–1325; ME < MF *avant* to the front < LL *ab ante* before (L: from before). See AB-, ANTE-]

A.V.C., 1. American Veterans' Committee. **2.** automatic volume control. Also, **AVC**

avdp., See **avoirdupois weight.**

a•ve (ä′vā, ā′vē), *interj.* **1.** hail; welcome. **2.** farewell; good-bye. —*n.* **3.** the salutation "ave." **4.** (*cap.*) See **Ave Maria.** [1200–50; ME < L: impv. 2d sing. of *avēre* to be well, fare well]

Ave., avenue. Also, **ave.**

a•ve at•que va•le (ä′we ät′kwe wä′le; *Eng.* ä′vē at′kwē vä′lē, ä′vā ät′kwā vä′lā), *Latin.* hail and farewell.

Ave•bur•y (āv′bə rē), *n.* **1. Baron.** See **Lubbock, Sir John. 2.** Also, **Abury.** a village in Wiltshire, England: site of one of the largest ceremonial megalithic structures in Europe.

a•vec plai•sir (A vek ple zēr′), *French.* with pleasure.

Av•e•don (av′i don′), *n.* **Richard,** born 1923, U.S. photographer.

A•vel•la•ne•da (ä ve′yä ne′thä), *n.* a city in E Argentina, near Buenos Aires. 330,654.

A•ve Ma•ri•a (ä′vā mə rē′ə), **1.** (*italics.*) the first two words of the Latin version of a prayer in the Roman Catholic Church, based on the salutation of the angel Gabriel to the Virgin Mary and the words of Elizabeth to her. **2.** a recitation of this prayer. **3.** the bead or beads on a rosary used to count off each prayer as spoken. Also called **Hail Mary.** [1200–50; ME; see AVE]

av•e•na•ceous (av′ə nā′shəs), *adj. Bot.* of or like oats. [1765–75; < L *avēnāceus,* equiv. to *avēn(a)* oats + *-āceus* -ACEOUS]

a•venge (ə venj′), *v.t.,* **a•venged, a•veng•ing. 1.** to take vengeance or exact satisfaction for: *to avenge a grave insult.* **2.** to take vengeance on behalf of: *He avenged his brother.* [1325–75; ME *avengen* < OF *avengier,* equiv. to *a-* A-⁵ + *vengier* < L *vindicāre;* see VINDICATE] —**a•venge′ful,** *adj.* —**a•veng′er,** *n.* —**a•veng′ing•ly,** *adv.*
—**Syn.** vindicate. AVENGE, REVENGE both imply to inflict pain or harm in return for pain or harm inflicted on oneself or those persons or causes to which one feels loyalty. The two words were formerly interchangeable, but have been differentiated until they now convey widely diverse ideas. AVENGE is now restricted to inflicting punishment as an act of retributive justice or as a vindication of propriety: *to avenge a murder by bringing the criminal to trial.* REVENGE implies inflicting pain or harm to retaliate for real or fancied wrongs; a reflexive pronoun is often used with this verb: *Iago wished to revenge himself upon Othello.* —**Ant. 1.** forgive.

av•ens (av′inz), *n., pl.* **-ens.** any of various plants of the genus *Geum,* of the rose family, having yellow, white, or red flowers. [1200–50; ME *avence* < OF < ML *avencia* kind of clover]

av•en•tail (av′ən tāl′), *n. Armor.* **1.** Also called **camail.** a mail tippet suspended from the lower edges of a 14th-century basinet as a protection for the neck, throat, and shoulders. **2.** ventail. [1300–50; ME < AF *aventaille,* equiv. to *a-* (< ?) + *ventaille* VENTAIL]

Av•en•tine (av′ən tīn′, -tin), *n.* **1.** one of the seven hills on which ancient Rome was built. —*adj.* **2.** of or pertaining to the Aventine. [1615–25; < L *Aventinus (mōns)* the Aventine (hill)]

a•ven•tu•rine (ə ven′chə rēn′, -rin), *n.* **1.** an opaque brown glass containing fine, gold-colored particles. **2.** any of several varieties of minerals, esp. quartz or feldspar, spangled with bright particles of mica, hematite, or other minerals. Also, **a•ven′tu•rin.** Also called **goldstone.** [1805–15; < F, equiv. to *aventure* chance (see ADVENTURE) + *-ine* -INE²; so called because metal particles are introduced into the molten glass pell-mell (*à l'aventure*)]

av•e•nue (av′ə nyōō′, -nōō′), *n.* **1.** a wide street or main thoroughfare. **2.** a means of access or attainment: *avenues of escape; avenues to greater power.* **3.** a way or means of entering into or approaching a place: *the various avenues to India.* **4.** *Chiefly Brit.* **a.** a wide, usually tree-lined road, path, driveway, etc., through grounds to a country house or monumental building. **b.** a suburban usually tree-lined residential street. [1590–1600; < F lit., approach, n. use of fem. ptp. of *avenir* < L *advenir* to come to. See A-⁵, VENUE]
—**Syn. 1.** See **street.**

Av•en•zo•ar (av′ən zō′ər, -zō är′), *n.* 1091?–116… Arab physician and writer in Spain: founder of Almoha… dynasty. Also called **Abumeron.**

a•ver (ə vûr′), *v.t.,* **a•verred, a•ver•ring. 1.** to asse… or affirm with confidence; declare in a positive or pe… emptory manner. **2.** *Law.* to allege as a fact. [135… 1400; ME < MF *averer* < ML *adverāre,* equiv. to *a…* AD- + *-vēr-* (< L *vērus* true) + *-ā-* thematic vowel … *-re* inf. suffix]
—**Syn.** See **maintain.**

av•er•age (av′ər ij, av′rij), *n., adj., v.,* **-aged, -ag•in…** —*n.* **1.** a quantity, rating, or the like that represents … approximates an arithmetic mean: *Her golf average is … the 90's. My average in science has gone from B to C th… semester.* **2.** a typical amount, rate, degree, etc.; nor… **3.** *Statistics.* See **arithmetic mean. 4.** *Math.* a qua… tity intermediate to a set of quantities. **5.** *Com.* **a.** … charge paid by the master of a ship for such services … pilotage or towage. **b.** an expense, partial loss, or da… age to a ship or cargo. **c.** the incidence of such an e… pense or loss to the owners or their insurers. **d.** an eq… table apportionment among all the interested parties … such an expense or loss. Cf. **general average, partic… lar average. 6. on the** or **an average,** usually; ty… cally: *She can read 50 pages an hour, on the avera…* —*adj.* **7.** of or pertaining to an average; estimated

average; forming an average: *The average rainfall there is 180 inches.* **8.** typical; common; ordinary: *The average secretary couldn't handle such a workload. His grades were nothing special, only average.* —*v.t.* **9.** to find an average value for (a variable quantity); reduce to a mean: *We averaged the price of milk in five neighborhood stores.* **10.** (of a variable quantity) to have as its arithmetic mean: *Wheat averages 56 pounds to a bushel.* **11.** to do or have on the average: *He averages seven hours of sleep a night.* —*v.i.* **12.** to have or show an average: *to average as expected.* **13. average down,** to purchase more of a security or commodity at a lower price to reduce the average cost of one's holdings. **14. average out, a.** to come out of a security or commodity transaction with a profit or without a loss. **b.** to reach an average or other figure: *His taxes should average out to about a fifth of his income.* **15. average up,** to purchase more of a security or commodity at a higher price to take advantage of a contemplated further rise in prices. [1485–95; earlier *averay* charge on goods shipped, orig. duty (< MF *avarie* < OIt *avaria* < Ar *'awārīyah* damaged merchandise), with -AGE r. *-ay*] —**av′er·age·a·ble,** *adj.* —**av′er·age·ly,** *adv.* —**av′er·age·ness,** *n.*

av′erage devia′tion. See **mean deviation.**

av′erage life′, *Physics.* See **mean life.**

av′erage rev′enue, the total receipts from sales divided by the number of units sold, frequently employed in price theory in conjunction with marginal revenue.

av′eraging light′ me′ter, *Photog.* an exposure meter that evaluates light measured from all parts of the picture area to generate an average reading. Cf. **center-weighted light meter.**

A·ve Re·gi·na Coe·lo·rum (ä′vā ri jē′nə che lôr′əm, -lōr′-), a Latin hymn in honor of the Virgin Mary as Queen of Heaven. [lit., Hail, Queen of Heaven]

A·ver·il (ā′vər il), *n.* a male given name. Also, **A′ver·ell.**

a·ver·ment (ə vûr′mənt), *n.* **1.** the act of averring. **2.** a positive statement. [1400–50; late ME *averrement* < MF. See AVER, -MENT]

A·ver·nus (ə vûr′nəs), *n.* **1.** a lake near Naples, Italy, looked upon in ancient times as an entrance to hell, from whose waters vile-smelling vapors arose, supposedly killing birds flying over it. **2.** hell. [< L < Gk *áornos* birdless, equiv. to *a-* A-[6] + *órn(is)* bird + *-os* adj. suffix] —**A·ver′nal,** *adj.*

A·ver·ro·ës (ə ver′ō ēz′), *n.* 1126?–98, Arab philosopher in Spain. Also, **A·ver′rho·ës′.**

Av·er·ro·ism (av′ə rō′iz əm, ə ver′ō-), *n.* the philosophy of Averroës, largely based on Aristotelianism and asserting the unity of an active intellect common to all human beings while denying personal immortality. Also, **Av′er·rho′ism.** [1745–55; AVERRO(ËS) + -ISM] —**Av′er·ro′ist, Av′er·rho′ist,** *n.* —**Av′er·ro·is′tic, Av′er·rho·is′tic,** *adj.*

a·verse (ə vûrs′), *adj.* having a strong feeling of opposition, antipathy, repugnance, etc.; opposed: *He is not averse to having a drink now and then.* [1590–1600; (< MF) < L *āversus* turned away, averted (ptp. of *āvertere*), equiv. to *ā-* A-[4] + *vert-* turn + *-tus* ptp. suffix] —**a·verse′ly,** *adv.* —**a·verse′ness,** *n.*
—**Syn.** unwilling, loath. See **reluctant.** —**Ant.** inclined, eager.
—**Usage.** See **adverse.**

a·ver·sion (ə vûr′zhən, -shən), *n.* **1.** a strong feeling of dislike, opposition, repugnance, or antipathy (usually fol. by *to*): *a strong aversion to snakes and spiders.* **2.** a cause or object of dislike; person or thing that causes antipathy: *His pet aversion is guests who are always late.* **3.** *Obs.* the act of averting; a turning away or preventing. [1590–1600; < L *āversiōn-* (s. of *āversiō*), equiv. to *āvers(us)* turned away (see AVERSE) + *-iōn-* -ION]
—**Syn. 1.** distaste, abhorrence, disgust. AVERSION, ANTIPATHY, LOATHING connote strong dislike or detestation. AVERSION is an unreasoning desire to avoid that which displeases, annoys, or offends: *an aversion to (or toward) cats.* ANTIPATHY is a distaste, dislike, or disgust toward something: *an antipathy toward (or for) braggarts.* LOATHING connotes a combination of hatred and disgust, or detestation: *a loathing for (or toward) hypocrisy, a criminal.* —**Ant. 1.** predilection.

a·ver·sive (ə vûr′siv, -ziv), *adj.* **1.** of or pertaining to aversion. **2.** of or pertaining to aversive conditioning. —*n.* **3.** a reprimand, punishment, or agent, used in aversive conditioning: *Antabuse is a commonly used aversive in the treatment of alcoholism.* [1590–1600; AVERS(ION) + -IVE] —**a·ver′sive·ly,** *adv.* —**a·ver′sive·ness,** *n.*

aver′sive condi′tioning, *Psychol., Psychiatry.* a type of behavior conditioning in which noxious stimuli are associated with undesirable or unwanted behavior that is to be modified or abolished, as the use of nausea-inducing drugs in the treatment of alcoholism. Also called **aver′sive ther′apy, aver′sion ther′apy.**

a·vert (ə vûrt′), *v.t.* **1.** to turn away or aside: *to avert one's eyes.* **2.** to ward off; prevent: *to avert evil; to avert an accident.* [1400–50; late ME < MF *avertir* << L *āvertere,* equiv. to *ā-* A-[4] + *vertere* to turn] —**a·vert′ed·ly,** *adv.* —**a·vert′er,** *n.* —**a·vert′i·ble, a·vert′a·ble,** *adj.*

A·ver·tin (ə vûr′tin), *Pharm., Trademark.* a brand of tribromoethanol.

A·ver·y (ā′və rē), *n.* **1. Milton,** 1893–1965, U.S. painter. **2.** a male given name: from Old English words meaning "elf" and "favor."

A·ves (ā′vēz), *n.* (*used with a plural v.*) a class of vertebrates comprising the birds. [1895–1900; < NL; L, pl. of *avis* bird]

A·ves·ta (ə ves′tə), *n.* a collection of sacred Zoroastrian writings, including the Gathas.

A·ves·tan (ə ves′tən), *n.* **1.** an ancient East Iranian language of the Indo-European family, the language of the Avesta. —*adj.* **2.** of or pertaining to the Avesta or its language. [1855–60; AVEST(A) + -AN]

A·vey·ron (A vā RÔN′), *n.* a department in S France. 278,306; 3387 sq. mi. (8770 sq. km). *Cap.:* Rodez.

AVF, all-volunteer force: referring to an armed force made up solely of volunteers during a period when there is no military draft, as the U.S. armed forces since the Vietnam War.

avg., average.

av·gas (av′gas′), *n. Aviation.* gasoline for use in piston-engined aircraft. [1940–45; AV(IATION) + GAS(OLINE)]

av·go·lem·o·no (äv′gō lem′ə nō′; *Gk.* äv′gô le′mô-nô), *n. Greek Cookery.* a soup or sauce made with beaten eggs, lemon juice, and usually chicken broth. [1960–65; ModGk *augolémono,* equiv. to *augó, abgó* egg (pron. *avyó*), classical Gk *tò ōión* the egg, pl. *tà ōiá* (cf. OO-), altered by fusion of article and noun, *υ* and *γ* filling vocalic hiatus, merger of sing. and pl. forms, and separation of the article as *t′* + *-lemono* var. (in compounds) of *lemóni* lemon < It *limone* << Pers; see LEMON]

avi-, a combining form meaning "bird," used in the formation of compound words: *aviculture.* [< L, comb. form of *avis*]

a·vi·an (ā′vē ən), *adj.* of or pertaining to birds. [1865–70; AVI- + -AN]

a′vian diphthe′ria, *Vet. Pathol.* See **fowl pox.**

a′vian influen′za, an acute, usually fatal viral disease of chickens and other domestic and wild birds except pigeons, characterized by sudden onset of symptoms including fever, swollen head and neck, bluish-black comb and wattle, and difficult respiration. Also called **bird plague, fowl plague.**

a·vi·an·ize (ā′vē ə nīz′), *v.t.,* **-ized, -iz·ing.** *Microbiol.* to diminish the infectivity of (a virus) by repeated culturing in chick embryos. Also *esp. Brit.,* **a′vi·an·ise′.** [AVIAN + -IZE]

a′vian leuko′sis, *Vet. Pathol.* leukosis.

a′vian pneu·mo·en·ceph·a·li′tis (no͞o′mō en sef′ə lī′tis, nyo͞o′-), *Vet. Pathol.* See **Newcastle disease.**

a′vian pox′, *Vet. Pathol.* See **fowl pox.**

a·vi·ar·y (ā′vē er′ē), *n., pl.* **-ar·ies.** a large cage or a house or enclosure in which birds are kept. [1570–80; < L *aviārium* a place where birds are kept, n. use of neut. of *aviārius* pertaining to birds. See AVI-, -ARY] —**a·vi·a·rist** (ā′vē ə rist), *n.*

a·vi·ate (ā′vē āt′, av′ē-), *v.t., v.i.,* **-at·ed, -at·ing.** to fly or fly in an aircraft. [1885–90; back formation from AVIATION]

a·vi·a·tion (ā′vē ā′shən, av′ē-), *n.* **1.** the design, development, production, operation, and use of aircraft, esp. heavier-than-air aircraft. **2.** military aircraft. [1865–70; < F; see AVI-, -ATION] —**a·vi·at·ic** (ā′vē at′ik, av′ē-), *adj.*

avia′tion badge′, wings.

avia′tion cadet′, one who trains to become an officer in an air force. [1940–45]

avia′tion med′icine, the branch of medicine dealing with the psychological, physiological, and pathological effects of flying in airplanes. Also called **aeromedicine.**

a·vi·a·tor (ā′vē ā′tər, av′ē-), *n.* a pilot of an airplane or other heavier-than-air aircraft. [1885–90; AVI- + -ATOR, modeled on F *aviateur*]

a′viator glass′es, eyeglasses with metal frames, and often tinted lenses, contoured to suggest the goggles once worn by aviators. [1965–70]

a·vi·a·trix (ā′vē ā′triks, av′ē-), *n., pl.* **-a·tri·ces** (-ā′trə sēz′, -ə trī′sēz). a woman who is a pilot; aviator. Also, **a·vi·a·tress, a·vi·a·trice** (ā′vē ā′tris). [1925–30; AVIAT(OR) + -TRIX]
—**Usage.** See **-trix.**

A·vi·ce·brón (ā′vē the brôn′, -se-), *n.* (*Solomon ben Judah ibn-Gabirol*) 1021?–58, Jewish poet and philosopher in Spain.

Av·i·cen·na (av′ə sen′ə), *n.* A.D. 980–1037, Islamic physician and philosopher, born in Persia.

a·vic·u·lar·i·um (ə vik′yə lâr′ē əm), *n., pl.* **-lar·i·a** (-lâr′ē ə). *Zool.* a protective zooid of a bryozoan colony, having movable jaws that can be snapped shut. [< NL; see AVI-, -CULE[1], -ARIUM] —**a·vic′u·lar′i·an,** *adj.*

a·vi·cul·ture (ā′vi kul′chər), *n.* the rearing or keeping of birds. [1875–80; AVI- + CULTURE] —**a′vi·cul′tur·ist,** *n.*

av·id (av′id), *adj.* **1.** enthusiastic; ardent; dedicated; keen: *an avid moviegoer.* **2.** keenly desirous; eager; greedy (often fol. by *for* or *of*): *avid for pleasure; avid of power.* [1760–70; < L *avidus,* equiv. to *av(ēre)* to crave + *-idus* -ID[4]] —**av′id·ly,** *adv.* —**av′id·ness,** *n.*
—**Syn.** AVID, EAGER, KEEN all share the sense of strongly desirous. AVID suggests a desire akin to greed, so strong as to be insatiable: *driven by an avid need for fame and recognition.* EAGER implies a desire that is strong and impatient but less than overpowering: *eager to try his hand at new tasks.* KEEN carries a sense of zest and active, alert desire: *an amateur painter, ever keen to try new techniques.*

av·i·din (av′i din, ə vid′in), *n. Biochem.* a protein, found in the white of egg, that combines with and prevents the action of biotin, thus injuring the animal that consumes it in excess by producing biotin deficiency. [1940–45; AVID + (BIOT)IN; so named from its affinity for biotin]

a·vid·i·ty (ə vid′i tē), *n.* **1.** eagerness; greediness. **2.** enthusiasm or dedication. [1400–50; late ME *avidite* < MF < L *aviditās.* See AVID, -ITY]

a·vid·ya (ə vid′yä), *n. Hinduism, Buddhism.* ignorance of the identity of oneself with Brahman, resulting in imprisonment within the cycle of birth and death. Cf. **vidya.** [< Skt *avidyā* ignorance, equiv. to *a-* ...]

a·vi·fau·na (ā′və fô′nə, av′ə), *n.* the birds of a given region, considered as a whole. [1870–75; AVI- + FAUNA] —**a′vi·fau′nal,** *adj.* —**a′vi·fau′nal·ly,** *adv.*

av·i·ga·tion (av′i gā′shən), *n.* aerial navigation. [AVI- + (NAVI)GATION] —**av′i·ga′tor,** *n.*

A·vi·gnon (A vē nyôN′), *n.* a city in and the capital of Vaucluse, in SE France, on the Rhone River: papal residence 1309–77. 93,024.

A·vi·la Ca·ma·cho (ä′vē lä′ kä mä′chô), **Ma·nuel** (mä nwel′), 1897–1955, president of Mexico 1940–46.

a vin·cu·lo mat·ri·mo·ni·i (ā ving′kyə lō′ ma′tri-mō′nē ī′, -nē ē′), *Law.* pertaining to or noting a divorce that absolutely dissolves the marriage bond and releases husband and wife from all matrimonial obligations: *a divorce a vinculo matrimonii.* [< L: from the bond of marriage]

a·vi·on·ics (ā′vē on′iks, av′ē-), *n.* **1.** (*used with a singular v.*) the science and technology of the development and use of electrical and electronic devices in aviation. **2.** (*used with a plural v.*) the devices themselves. [1945–50; AVI(ATION) + (ELECTR)ONICS] —**a′vi·on′ic,** *adj.*

a·vi·o·pho·bi·a (ā′vē ə fō′bē ə, av′ē-), *n. Psychiatry.* fear of flying in an airplane or other aircraft. [perh. AVI(ATION) + -O- + -PHOBIA]

a·vir·u·lent (ā vir′yə lənt, ā vir′ə-), *adj.* (of organisms) having no virulence, as a result of age, heat, etc.; nonpathogenic. [1895–1900; A-[6] + VIRULENT] —**a·vir′u·lence,** *n.*

A·vis (ā′vis), *n.* a female given name: from a Latin word meaning "bird."

a·vi·so (ə vī′zō), *n., pl.* **-sos.** a boat used esp. for carrying dispatches; dispatch boat. [1625–35; < Sp, n. deriv. of *avisar* to ADVISE]

a·vi·ta·min·o·sis (ā vī′tə mə nō′sis), *n. Pathol.* any disease caused by a lack of vitamins. [1910–15; A-[6] + VITAMIN + -OSIS] —**a·vi·ta·min·ot·ic** (ā vī′tə mə not′ik), *adj.*

A·viv (ä vēv′), *n. Chiefly Biblical.* the seventh month of the Jewish year, equivalent to Nisan of the modern Jewish calendar. Ex. 34:18. Also, **Abib.** [< Heb *ābhībh* lit., ear of grain]

Av·lo·na (av lō′nə), *n.* former name of **Vlorë.**

avn., aviation.

A-V node. See **atrioventricular node.** Also, **AV node.**

a·vo (ä′vo͞o), *n., pl.* **a·vos.** a money of account of Macao, the 100th part of a pataca. [1905–10; < Pg: lit., trifle, shortening of *oitavo* eighth; see OCTAVE]

av·o·ca·do (av′ə kä′dō, ä′və-), *n., pl.* **-dos. 1.** Also called **alligator pear.** a large, usually pear-shaped fruit having green to blackish skin, a single large seed, and soft, light-green pulp, borne by the tropical American tree *Persea americana* and its variety *P. adrymifolia,* often eaten raw, esp. in salads. **2.** the tree itself. [1690–1700; alter. of Sp *abogado* lit., lawyer (see ADVOCATE), by confusion with MexSp *aguacate* < Nahuatl *āhuacatl* avocado, testicle; cf. ALLIGATOR PEAR]

avocado,
Persea americana

av·o·ca·tion (av′ə kā′shən), *n.* **1.** something a person does in addition to a principal occupation, esp. for pleasure; hobby: *Our doctor's avocation is painting.* **2.** a person's regular occupation, calling, or vocation. **3.** *Archaic.* diversion or distraction. [1520–30; < L *āvocātiōn-* (s. of *āvocātiō*) a calling away. See A-[4], VOCATION] —**av′o·ca′tion·al,** *adj.* —**av′o·ca′tion·al·ly,** *adv.*

av·o·cet (av′ə set′), *n.* any of several long-legged, web-footed shorebirds constituting the genus *Recurvirostra,* having a long, slender, upward-curving bill. [1760–70; < F *avocette,* prob. erroneous sp. for NL *avosetta* < It < Upper It (< Venetian)]

av·o·di·re (av′ə də rā′), *n.* the hard, light-colored wood of a West African tree, *Turraeanthus africana,* of the mahogany family, used for making furniture. [1930–35; < F *avodiré,* said to be < Agni, a Kwa language of the Ivory Coast]

A·vo·ga·dro (ä′və gä′drō; *It.* ä′vô gä′dRô), *n.* **Count A·ma·de·o** (ä′mä de′ô), 1776–1856, Italian physicist and chemist.

A′voga′dro's law′, *Chem.* the principle that equal volumes of all gases at the same temperature and pressure contain the same number of molecules. Thus, the molar volume of all ideal gases at 0° C and a pressure of 1 atm. is 22.4 liters. [1870–75; named after A. AVOGADRO]

A′voga′dro's num′ber, *Chem.* the constant, 6.02×10^{23}, representing the number of atoms in a gram atom or the number of molecules in a gram molecule. *Symbol:* N Also called **A′voga′dro con′stant.** Cf. **Loschmidt's number.** [1925–30; see AVOGADRO'S LAW]

a·void (ə void′), *v.t.* **1.** to keep away from; keep clear